

Hydrogen Station Equipment Performance (HyStEP) Device

Operation and Maintenance Manual



CAUTION:

This manual is for use by trained personnel only.

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Disclaimer

This manual incorporates safety guidelines and recommendations; however, it is not intended that this manual cover all situations. It is the customer's responsibility to meet all local safety requirements and to ensure safety during operation and maintenance of the Hydrogen Station Equipment Performance (HyStEP) Device

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1 INTRODUCTION

The Hydrogen Station Equipment Performance (HyStEP) Device is intended to be a surrogate for FCEVs that can be used to test hydrogen station fueling performance. The device includes three Type IV 70 MPa tanks capable of storing a total of 9 kg H₂ that are instrumented with pressure and temperature sensors. The tanks are connected to a 70 MPa receptacle equipped with pressure and temperature sensors as well as infrared communications integrated with a data acquisition, analysis, and control system. The HyStEP Device is capable of performing tests defined in the test method standard CSA HGV 4.3 to ensure that hydrogen stations meet the fueling protocol standard SAE J2601-2014. These include IrDA communication tests, fault detection tests, and communication and non-communication fills.

This manual contains operational procedures, equipment specifications, & safety information. To help ensure safe and trouble-free operation of the HyStEP device, read this manual carefully and follow its recommendations.

All specifications and descriptions are accurate at the time of approval. Because improvement is a constant goal at Powertech, we reserve the right to make changes in specifications at any time without notice and without obligation.



1.1 HOW TO USE THIS MANUAL

This manual is only applicable to the HyStEP device with Model # HYSTEP-120-1 and serial number: 1000-15. Keep this manual in the tool chest in the Utility Room as a handy reference for the safe and proper use of the equipment.

Illustrations, photos, and drawings complement the words of this manual to best explain how to operate the HyStEP device. By reading this manual from cover to cover, you can find out about the features, important safety information, and operating procedures of the HyStEP device.

This manual can also be used as training guidelines for people who want to operate the HyStEP. It is recommended to have the HyStEP device available during training because some of the operations are best learned in front of the equipment.

The following symbols are used throughout this manual to highlight instructions, safety-critical information and other key information:



Note: Provides important notes and useful information.



Caution: Provides cautionary information related to equipment conditions as well as health and safety. Failure to observe and follow the instructions may result in equipment failure and/or injury to people around the device.



Danger: Provides information on potential dangers related to equipment conditions as well as health and safety. Failed to observe and follow the information may result in equipment failure, injury, and/or fatalities to people around the device.



Note: A good place to start is the Table of Contents or HyStEP at a Glance

1.2 HYSTEP AT A GLANCE

This section provides a pictorial overview of the HyStEP layout to help you locate the essential equipment. Review Figure 1 to Figure 3 to familiarize yourself with the equipment location and orientation of the HyStEP device.

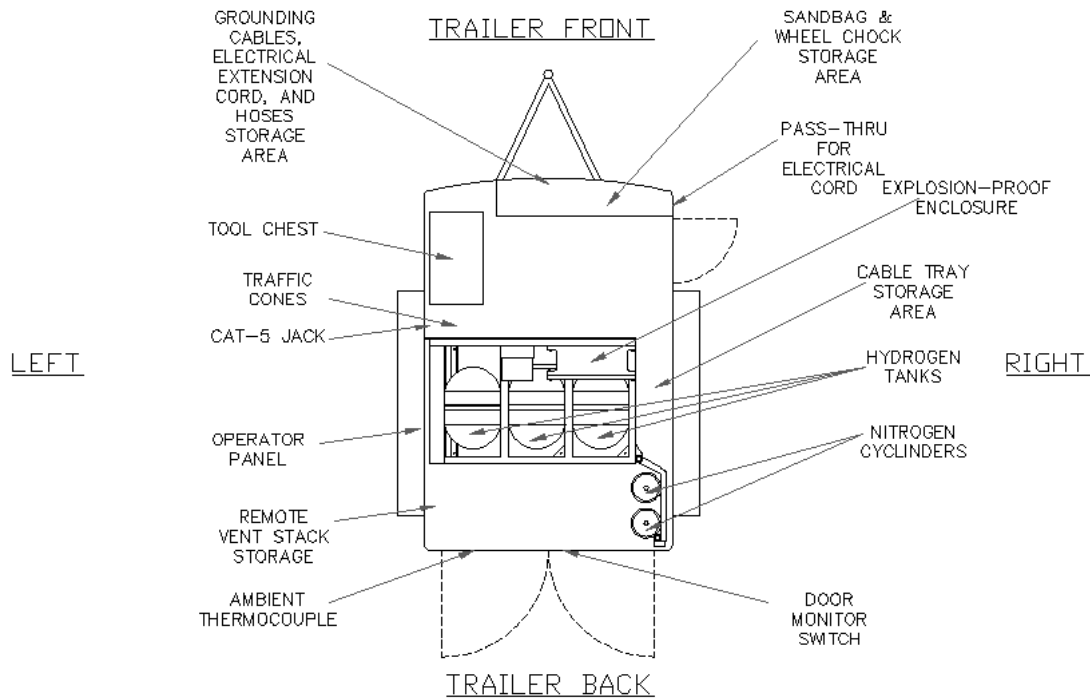


FIGURE 1 – EQUIPMENT LAYOUT (SECTION VIEW FROM TOP)

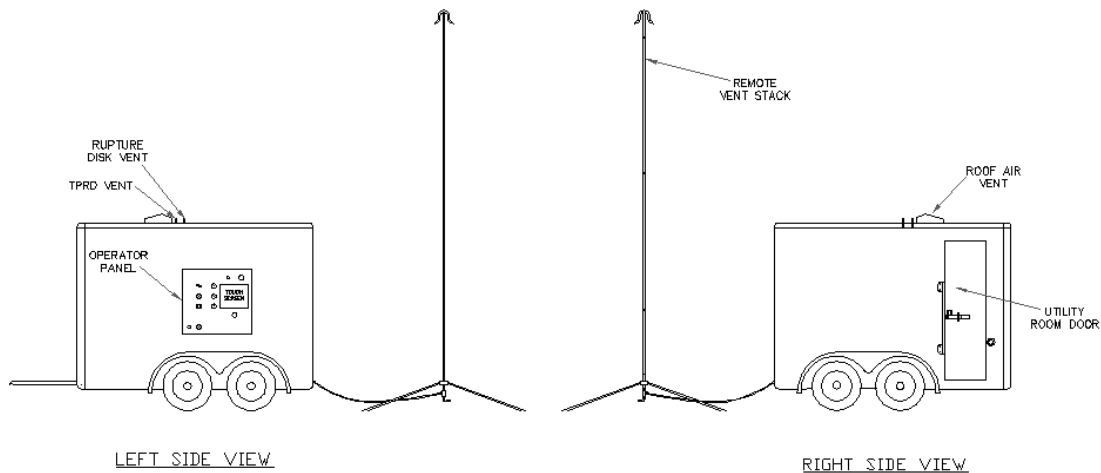


FIGURE 2 – EQUIPMENT LAYOUT (RIGHT & LEFT SIDE VIEW)

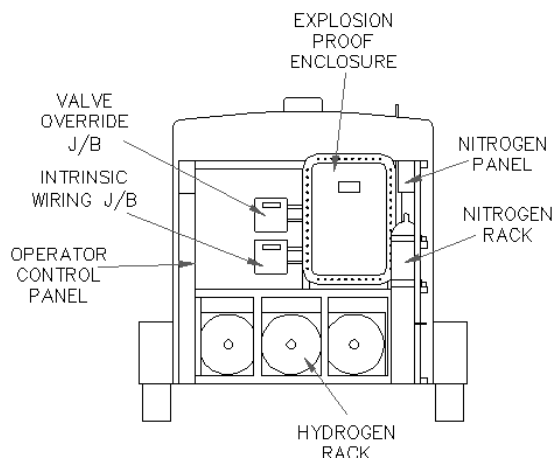


FIGURE 3 – EQUIPMENT LAYOUT (SECTION VIEW FROM BACK)

1.3 ESSENTIAL SAFETY EQUIPMENT

The HystEP device is equipped with a number of safety features to mitigate the risks associated with handling compressed hydrogen. The operator shall carefully read all sections related to hydrogen and equipment safety.

Gas Detection – there are two (2) hydrogen sensors installed to detect the hydrogen level [%LEL] inside the trailer.

Heat Detector – there are two (2) heat sensors installed to detect fire hazards inside the trailer.

Pressure Relief Device (PRD) – a rupture disc pressure relief device is installed in the nitrogen purge system to prevent over-pressurization. Also, there is a spring-loaded self-reseating safety relief valve at the nitrogen pneumatic supply line.

Thermally-activated Pressure Relief Device (TPRD) – each hydrogen tank is fitted with a thermally-activated pressure relief device to release all the gas inside the tank under high temperature (activated at about 110°C).

Intrinsic Safety (IS) Barrier – field sensors such as pressure transducers & thermocouples in hazardous areas are isolated with IS barriers to achieve energy limitation when faults occur.

Explosion-Proof Enclosure – a number of explosion-proof enclosures are used in HyStEP to house electrical components, devices, and connections in hazardous locations where energy limitation technique is not possible.

Ventilation – to minimize risk of hydrogen accumulation when leaks occurs, there is a manual roof vent along with the back door monitoring to provide natural ventilation when HyStEP is in use.

Sandbags – stored in the Utility Room and used to weigh down remote vent stack at the base to increase the stability of the 17' 9" high structure.

Wheel Chocks – stored in the Utility Room are provided to secure the trailer when detached from the towing vehicle.

Traffic Cones – stored in the Utility Room are provided to cone off the area where the trailer and remote vent stack are located from the general public.

Cable Trays – stored in the Utility Room are provided to house electrical cords and gas hoses where needed to protect them from physical damages as well as to mitigate tripping hazards.

Audible & Visual (AV) Alarm – the automation & data acquisition system (cDAQ) is equipped with an AV alarm device in the Operator Panel to notify the operator and personnel nearby the trailer when abnormal operating conditions occur.

1.4 IDENTIFYING HAZARDOUS CONDITIONS

Although the HyStEP device has numerous safety features to monitor hazardous conditions and to reduce the risk of injury, **it is the responsibility of the HyStEP operator to constantly look out for hazardous conditions and to immediately address such hazardous conditions in a safe manner.** Below is a list of potential hazardous conditions to assist the operator to identify them and to look out for any other hazards:

- Personnel injury hazard, fire hazard, or knock-over hazard if the remote vent stack is located at suboptimal locations such as high traffic areas.
- Fire or explosion hazard if the explosion-proof enclosures are not closed when hydrogen is present in the system and leaks occur.
- High level of hydrogen accumulated inside the trailer if the trailer doors and roof vent are closed during operation when hydrogen is present in the system and leaks occur.
- Trailer may roll if wheel chocks not used to secure the trailer when parked and not attached to the tow vehicle.
- Electrical hazards may occur if the trailer is not electrically grounded.
- Electrical hazards if the trailer electrical cord is connected to Non-GFCI outlet when used outdoors.
- General public may enter the hazardous areas accidentally if traffic cones are not used around remote vent stack and trailer
- Tip-over hazard if sandbags are not applied at the base of the remote vent stacks
- Hose whip hazard if sandbags are not used at the hose ends and connections.

- Tripping hazard and physical damages if cable trays are not used to protect electrical cords or gas hoses on the ground.

1.5 IN CASE OF EMERGENCY

Before operating the HyStEP device, the operator shall prepare himself/herself in case of emergency during the operation. The following scenarios are to prepare the operator to handle some situations; however, contact the local emergency departments immediately if needed.

1.5.1 Leak Detected

If a leak is detected in the system plumbing, immediately shut down the system by pressing the ESD button on the Operator Panel. Ensure that no sources of ignition are introduced and allow the hydrogen gas to remain in the isolated portion of the system to vent to atmosphere. When the gas has vented sufficiently, purge the affected system components and replace or repair the leaking component.

If an unstoppable leak is detected from a cylinder, allow the hydrogen gas to vent to atmosphere. Completely venting the hydrogen gas out of an entire cylinder through a small leak may take a long time and could create a dangerous concentration of hydrogen gas. Therefore, purging the cylinder may be necessary.

1.5.2 Exposure to Fire

If the trailer is exposed to sufficient heat generated from a fire, the thermal pressure relief device (TPRD) will automatically vent the entire contents of the affected storage cylinder(s) through the TPRD manifold outlets. This allows the contents of the cylinders to be vented without having a dangerous increase in pressure due to the added heat energy from the fire.

All the cylinders are equipped with thermally activated pressure relief devices (TPRD). The TPRDs, when activated by high temperature, release the cylinder contents into the vent stack. Each stack should be opened bi-annually to verify that the stacks are empty.

1.5.3 Trailer Involved in Collision

If the trailer is involved in a collision or accident involving another vehicle or object, careful inspection of the cylinders and components is required to ensure physical damage has not occurred. After a collision, contact Powertech Labs Inc. prior to further system operation for a damage assessment and recommended actions.

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2 IMPORTANT SAFETY INFORMATION

2.1 HYDROGEN SAFETY

All fuels, including hydrogen, are dangerous because they are chemically reactive. It is this reactivity which makes fuels excellent sources of energy. Hydrogen is not inherently more dangerous than any other fuel, such as natural gas or gasoline, but its properties are unique and it must be handled with appropriate care. Hydrogen leaks form the basis of all gaseous hydrogen hazards; without a leak there is no opportunity for hydrogen to mix with air, and therefore no basis for flammability or asphyxiation hazards.

2.2 HYDROGEN LEAK POTENTIAL

Due to the small molecular size of gaseous hydrogen, it can diffuse through many materials considered airtight or impermeable to other gases. This property makes hydrogen more difficult to contain than other gases. Fuel lines, unwelded connections, and non-metal seals such as gaskets, O-rings, pipe thread compounds and packings present potential leakage or permeation sites.

Hydrogen leaks are dangerous in that they pose a risk of fire when mixed with air. However, the small molecule size that increases the likelihood of a leak also results in very high buoyancy and diffusivity, so leaked hydrogen rises and becomes diluted quickly, especially outdoors. This results in a highly localized region of flammability that disperses quickly. Ambient wind or other motion further speeds dispersion, thus reducing the region of flammability.

Constant exposure to hydrogen causes a phenomenon known as hydrogen embrittlement in many materials. Hydrogen embrittlement can lead to leakage or catastrophic failures in metal and non-metallic components. Stainless steel components are not susceptible to hydrogen embrittlement, which mitigates this risk.

Hydrogen leaks in any hydrogen storage system are mitigated by design and ongoing maintenance. Materials used are resistant to metal embrittlement, are designed for hydrogen use, and are fire resistant. Maintenance procedures include leak tests and inspections.

2.3 HYDROGEN FLAMMABILITY

Hydrogen gas becomes flammable or explosive when mixed with air at certain concentrations. Oxygen and hydrogen mix when air is allowed to enter a hydrogen vessel, or when hydrogen leaks into the atmosphere.

The flammability range of a gas is defined in terms of its lower flammability limit (LFL) and its upper flammability limit (UFL). The LFL of a gas is the lowest gas concentration that will support a self-propagating flame when mixed with air and ignited. Below the LFL, there is not enough fuel present to support combustion; the fuel/air mixture is too lean. The UFL of a gas is the highest gas concentration that will support a self-propagating flame when mixed with air and ignited. Above the UFL, there is not enough oxygen present to support combustion; the fuel/air mixture is too rich. Between the two limits is the flammable range in which the gas and air are in the right proportions to burn when ignited.

One consequence of the UFL is that stored hydrogen is not flammable while stored due to the absence of oxygen in the cylinders. The hydrogen only becomes flammable in the peripheral areas of a leak where the hydrogen mixes with the air in sufficient proportions.

Hydrogen is flammable over a wide range of concentrations in air (4 – 75%) and it is explosive over a wide range of concentrations (15 – 59%) at standard atmospheric temperature. As a result, even small leaks of hydrogen have the potential to burn or explode.

A flammable hydrogen mixture is easily ignited by a spark, open flame or hot surface. A common source of sparks is through static discharge. To exacerbate this, hydrogen has the distinctive property of low electro-conductivity so that the flow or agitation of hydrogen gas may, by itself, generate electrostatic charges. For this reason, all hydrogen conveying equipment must be thoroughly grounded.

Hot surfaces result in spontaneous ignition at temperatures greater than 500 °C (932 °F). This is the auto ignition temperature of hydrogen, and is the minimum temperature required to initiate self-sustained combustion in a combustible fuel mixture in the absence of a source of ignition.

Hydrogen flames are very pale blue and are almost invisible in daylight due to the absence of soot. Visibility is enhanced by the presence of moisture or impurities (such as sulphur) in the air. Hydrogen flames are readily visible in the dark or subdued light. A hydrogen fire can be indirectly visible by way of emanating “heat ripples” and thermal radiation, particularly from large fires. In many instances, flames from a hydrogen fire may ignite surrounding materials that do produce smoke and soot during combustion.

In many respects, hydrogen fires are safer than gasoline fires. Hydrogen gas rises quickly due to its high buoyancy and diffusivity whereas gasoline spreads laterally. Consequently, hydrogen fires are vertical and highly localized and can only exist in the region of a leak where pure hydrogen mixes with air at sufficient concentrations. Hydrogen emits non-toxic combustion products when burned.

2.4 HYDROGEN’S PHYSICAL EFFECTS

Pure hydrogen is odourless, colourless and tasteless. Compounds such as mercaptans and thiophanes that are used to scent natural gas are typically not added to hydrogen.

Hydrogen is non-toxic but can act as a simple asphyxiant by displacing the oxygen in the air.

In an enclosed area, small leaks pose little danger of asphyxiation, whereas large leaks can be a serious problem since the hydrogen diffuses quickly to fill the volume. The potential for asphyxiation in unconfined areas is almost negligible due to the high buoyancy and diffusivity of hydrogen.

2.5 OPERATOR RESPONSIBILITIES

The operator shall

- Constantly look out for hazardous conditions and address such conditions immediately.

- Familiarize himself or herself of this manual and observe the safety & hazard warnings at all time.
- Maintain the safety of the trailer, the HyStEP component, property, and the general public around the trailer.
- Report any defects, safety concerns, and/or operational anomalies to the owner's representative and be ready to lock out the device if they pose safety concerns (ex: leaks, high pressure, high flow rate).
- Ensure the latest version of the test procedures in CSA HGV 4.3 are being used
- Keep the device (whether operating or not) in the suitable environmental conditions as outlined in Section 2.12 - Storage.
- Not attempt to alter any of the mechanical components, electrical devices, or cDAQ software codes for any reasons without written authorization from the manufacturer. Such alternation may void the manufacturer warranty and/or result in unsafe operating conditions

2.6 PERSONAL PROTECTIVE EQUIPMENT

2.6.1 Protective Equipment

Protective equipment should be used while working on or operating the HyStEP device. Work boots with steel inserts to protect toes shall be used. Hard hats shall be worn while working near the remote vent stack and/or when ladder is used around HyStEP.

2.6.2 Eye Protection

When compressed gas is present in the system, eye protection shall be applied at all time.

2.6.3 Hearing Protection

Ears should be protected in a noisy environment such as defueling. Disposable earplugs and earmuffs are recommended.

2.6.4 Clothing

High visibility clothing shall be worn at all time and fire resistant clothing should be worn when working with flammable gas. Gloves shall be used when setting up the HyStEP, moving objects, and/or turning hand valves (system components can get as low as -40°C). Long sleeved shirts with cuffs buttoned and long-legged pants should be worn when working near the remote vent stack while venting and/or when a ladder is used around HyStEP when the system is pressurized

2.7 UNDERSTAND HYSTEP BEFORE YOUR 1ST USE

HyStEP is a device that simulates the Compressed Hydrogen Storage System (CHSS) of a Hydrogen Fuel Cell Vehicle (HFCV) to test the safety and performance of hydrogen dispensers up to a maximum hydrogen pressure of 87.5MPa.

The device receives hydrogen gas from the dispenser. A computerized instrumentation system (cDAQ) sequences components and measures the temperature & pressure of the incoming hydrogen at various locations. It also monitors the safety of the system and provides alarm notifications if any of the monitored parameters are out of normal operating range.

The system requires 120VAC/15A/60Hz electrical power and adequate nitrogen supply to operate.

The cDAQ is equipped with a cellular modem that connects to the Internet via cellular network as well as acts as an Ethernet router of the local area network within the HyStEP device. Computers can be connected to the local area network via the CAT-5 jack located in the utility room for file download and administration.

The mechanical and electrical components of HyStEP are housed inside an enclosed utility trailer with 7,000 lb GVWR and can be towed by SUVs, trucks, forklifts, or utility vehicles that are rated for such towing capacity. The HyStEP trailer can be towed around on paved roads/highways as any other dual-axial utility trailers.

2.8 PRE-TRIP INSPECTION

Before towing the HyStEP device on a road trip, the operator should perform a pre-trip inspection on the exterior and interior of the device.

Interior

- Make sure parts are properly secured such as electrical cords, grounding cables, gas hoses, remote vent stack components, and nitrogen cylinders
- Make sure nitrogen supply is disconnected from the nitrogen panel and caps are installed on the nitrogen cylinders
- Make sure the HyStEP tools, supplies, and spare parts are in place such as cones, sandbags, and cable trays

Exterior

- Check the trailer tire pressure
- Make sure the doors are closed and locks are in place.
- Make sure the roof vent is closed and secured
- Check the trailer signal lights
- Check the charge on the battery for the trailers emergency brakes

- Make sure the caps on the trailers vent stack outlets are installed

System




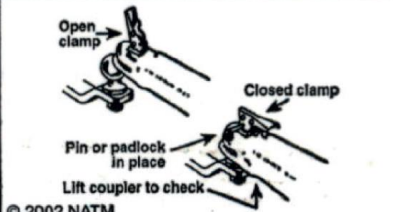
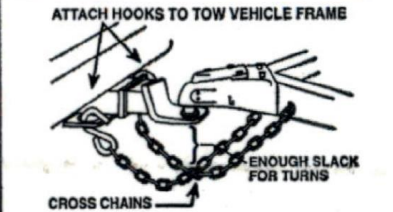
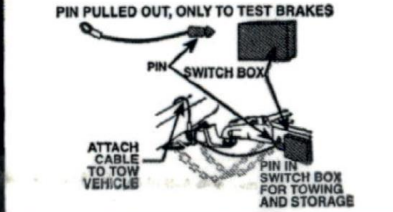
- Connect the HyStEP to an electrical outlet to check the cDAQ & touchscreen operations
- Check the hydrogen tank pressure against the last record for leaks
- Make sure nitrogen supply is adequate or have it ready on site
- Check the pressure gauges to ensure the system pressure is at a safe level for travel
- Make sure all pressure regulators and manual valves are closed (excluding the tank isolation valves (NV 3, NV 4, and NV 5))



Caution: If the tanks or other pressure components are opened to the atmosphere, the system must be purged prior to the trip.

2.9 TOWING

Serious damage or injury can occur from improper towing. Make sure to follow the towing procedures outlined in this manual and in the Forest River Trailer Manual (see Component Manual Section of Appendix). Warnings for towing are shown below.

 WARNING	 WARNING	 WARNING
Uncoupling will cause trailer to come loose from tow vehicle. You must: 1. CHECK that ball LOAD RATING is same as or greater than coupler LOAD RATING. 2. CHECK that ball SIZE is same as coupler. 3. CLOSE COUPLER CLAMP on ball. 4. LIFT coupler upwards to test that it will not separate from ball. 5. LOCK coupler clamp with pin or padlock.	ALWAYS use safety chains. Chains hold trailer if connection fails. You must: 1. CROSS chains underneath coupler. 2. ALLOW slack for trailer to turn. 3. ATTACH chain hooks securely to tow vehicle frame.	Trailer can roll if it comes loose. Electric safety brake applies when cable pulls pin out of switch box. 1. PULL hard to get pin out of switch box. 2. CHECK brake by PULLING TRAILER with tow vehicle. 3. ATTACH pin Cable to tow vehicle so pin will be pulled out if trailer separates. 4. Promptly REPLACE pin in switch box.
		

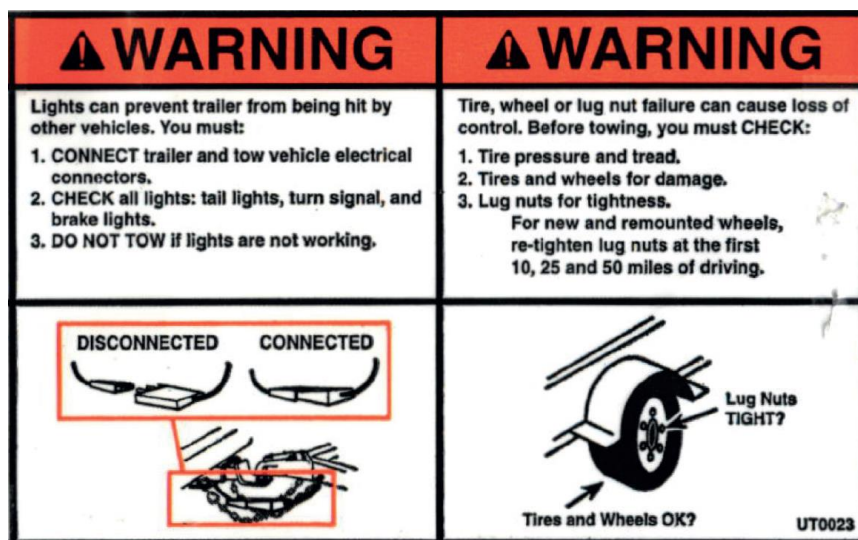


FIGURE 4 – MANUFACTURER WARNINGS FOR TOWING THE TRAILER

2.10 SITE INSPECTION

To ensure safe operation of the HyStEP device, users must follow the set-up procedures outlined in this manual. Incorrect set up of equipment or setup in suboptimal locations could cause injury and/or damage to the device. Review the steps below to determine whether the site is suitable and safe for operating the HyStEP.

1. Identify the locations of the hydrogen dispenser to be tested and check the surrounding for clearance
2. Evaluate the site for the safest location for setting up the remote vent stack
3. Use traffic cones to secure the areas
4. Locate your 120VAC electrical power outlet (a total length of 80 feet electrical cord) and at least 15 feet away from trailer
5. Locate your grounding point
6. Check the nitrogen supply
7. If all of the above is satisfied, then refer to “Setting up the HyStEP – Section 6” for detailed procedures; otherwise, do not operate the HyStEP and contact the dispenser owner for resolutions and/or further instructions.

2.11 WARRANTY & CONTACT INFORMATION

Powertech Labs Inc. (PLI) provides assurance that all the devices, components, and equipment supplied and installed by PLI will perform to the performance specifications for a 1-year period from the completion date of the system training/demonstration by PLI representatives at *National Renewable Energy Laboratory on December 4, 2015*

The 1-year warranty period of the system expires on: **12:00:00am December 3, 2016.**

Note: any deletion, additions, or alternations of the system without written approval from the manufacturer may void the warranty, damage the system, and/or result in unsafe operations.

To make a warranty claim or enquiry about warranty information, please contact the owner's representative or PLI and quote reference number PL-00742.

HyStEP Owner:

The United States Department of Energy (DOE)

Owner's Representative:

*Terry Johnson, Sandia National Laboratories
P.O. Box 969, Livermore, California, 94551-0969
Office: +1 (924)-294-2512
Fax: +1 (925)-294-3870*

Powertech Labs Inc.:

*Gas Systems Engineering, Powertech Labs Inc.
12388 – 88th Avenue, Surrey, British Columbia, Canada, V3W 7R7
<http://www.powertechlabs.com>
Office: +1 (604) 590-7500
Fax: +1 (604) 590-6611*

2.12 STORAGE

The HyStEP device is protected against, wind, rain, snow, and sunlight by the utility trailer. Care should be taken when the HyStEP device is not to be used for a long time.

- Store either indoor or outdoor providing the environmental conditions are met: -40 to 85 °C and 5 to 95% relative humidity (noncondensing).
- Wash the exterior of the trailer with water
- Park and secure the trailer as level as possible front to rear and side to side
- Purge the system with nitrogen
- Inspect the opening of the vent stack on the roof to make sure the caps are properly in place. If not, there may have been pressure relief device (PRD) activation and system should be thoroughly checked (refer to Maintenance Section).
- Drain the Thermal Pressure Relief Device (TPRD) vent stack for water using drain port at the bottom.
- Record/label the system pressure in the three hydrogen tanks and the nitrogen cylinders for later comparison against leaks

- Close all pressure regulators and hand valves (excluding the tank isolation valves (NV 3, NV 4, and NV 5))
- Disconnect the electrical power
- Disconnect the nitrogen supply
- Close the roof vent (if stored outside)
- Close all doors
- Lock all doors and the trailer hitch when stored outside.
- Trickle charge the 12VDC battery of the trailer e-brake system

3 HYSTEP OVERVIEW

3.1 OVERVIEW

The HyStEP device has 3 main processes:

1. Fueling
2. Defueling
3. Purging

Fueling is when the majority of tests are conducted. This process involves flowing gas from the dispenser into the HyStEP device via a receptacle and several other components prior to the tanks. There are 3 tanks that can be fueled, allowing for a maximum capacity of 9.3 kg. During a fill, the test type must be selected (as per CSA HGV 4.3) and data will be logged so it can be analyzed afterwards.

Defueling is primarily used before transporting the device or when all the tanks are full. Gas is vented through a remote vent stack and the defueling flow rate is controlled using an adjustable regulator and needle valve.

Purging is used to either remove air from the system or to remove hydrogen from the system. It is conducted using nitrogen and occurs prior to transport or after any maintenance is conducted that requires air to enter the system. A nitrogen T or K cylinder is used and the nitrogen flow is controlled using an adjustable regulator and needle valve. The gas is then vented through the remote vent stack and this process is repeated 3 times to ensure the removal of the unwanted gas.

3.2 SPECIFICATIONS

Table 3-1, Table 3-2, and Table 3-3 show the specifications for the electrical system, utility trailer and the hydrogen system respectively.

TABLE 3–1 –ELECTRICAL SPECIFICATIONS

Description	Specification
Model	HYSTEP-120-1
Serial #	1000-15
Voltage	120VAC/24VDC
Amperage	15/10 A
Frequency (AC)	60 Hz
Phase	1Ø/DC
Temperature Code	T3

Description	Specification
Operating Temperature	–10°C to 45°C
Relative Humidity	10 to 90% Relative Humidity (noncondensing)
IRDI	200392 IRDI Test Signal Generator with Modbus 200019 IR Transmitter
Control System	National Instruments® cDAQ

TABLE 3–2 – UTILITY TRAILER SPECIFICATIONS

Description	Specification
Utility Trailer	
Model	OSTW710TA2
Manufacturer	Continental Cargo
Axle	Dual Axle, Torsional Suspension
Overall Length	13' 10"
Overall Width	8' 6"
Overall Height	8' 6"
Interior Length	10' 7"
Interior Width	6' 8"
Interior Height	6' 9"
Rear Door	Double
Rear Door Width	6'
Rear Door Height	6'
Hitch Weight	154 lb
Hitch Height	18 in
Ball Size	2 – 5/16"
Platform Height	18"
GVWR	7,000 lbs
Curb Weight	1,540 lb
Payload	5,460 lb
Brakes	Electric
Tires	ST205/75R15/C
Wheels	5-bolt

Description	Specification
Frame	4" Tube
Wheel Torque Spec.	95 ft.-lbs
Recommended Tire Pressure	50 PSI/345 KPa

TABLE 3–3 – GAS SYSTEM SPECIFICATIONS

Description	Specification
Hydrogen System	
Maximum/Minimum Pressure Rating	87.5 MPa (12,690 psig) / 0.5 MPa (72.5 psig)
Gas Temperature Range	–40°C to 85°C
Tanks	Three Quantum “Type 4” composite tanks Part Number: 116729 Serial Number:H14120763GM016, H14120763GM019, and H14120763GM012 76L Internal Volume at Service Pressure each
Receptacle	700 bar: WEH TN1 P70
Nitrogen System	
Max. Cylinder Pressure	20.7 MPa (3,000 psig)
Max. Purge System Pressure	10.3 MPa (1,500 psig)
Max. Instrument Pressure	0.7 MPa (100 psig)

3.3 APPROVALS

The HyStEP device does not bear any single approval/certification/marks. All the components used in the HyStEP were properly engineered to meet the project requirements.

All electrical equipment has either: UL, CSA, CE, TBD, or IP67 approvals. The hydrogen equipment has either: ASME, ASTM, ECE, CGA, or NACE approvals. The receptacle is registered to E1 00 0010 (Regulation (EC) No. 79/2009) and SAE J2600:2002. Storage tanks were qualified in accordance with NGV2-2007 (R2012). The entire hydrogen system was designed to ASME B31.12: Hydrogen Pressure Piping Code (2011) and NFPA 2 was used as a guideline when applicable.

3.4 EQUIPMENT LAYOUT & COMPONENTS

The HyStEP device is split into two rooms, the utility room and gas room. Components in each of these rooms are listed below.

1. Utility Room

- a. Tool chest with spare parts and tools inside
 - b. Storage for electrical cord and hydrogen vent hose
 - c. Sandbag storage
 - d. Cable tray storage
 - e. Safety cone storage
 - f. Gas detection probe
 - g. Heat detection probe
 - h. Rooftop vent
 - i. LED Light
2. Gas Room
- a. Hydrogen storage tanks
 - b. Air actuated control valves
 - c. Rupture disk style pressure relief device
 - d. Thermal Pressure Relief Devices (TPRD's)
 - e. Various sensors and fittings
 - f. Gas detection probe
 - g. Heat detection probe
 - h. Nitrogen cylinder storage
 - i. Explosion proof box for unclassified electrical equipment
 - j. Remote vent stack storage
 - k. Valve over-ride panel
 - l. Intrinsically safe wiring junction box
 - m. LED Light
 - n. Back side of main control panel which includes:
 - i. HMI
 - ii. ESD button
 - iii. Audible/Visual Alarm
 - iv. Hydrogen receptacle, gauges, regulator, needle valve

Figure 5 below shows the location of these rooms within the trailer as well as the trailer layout.

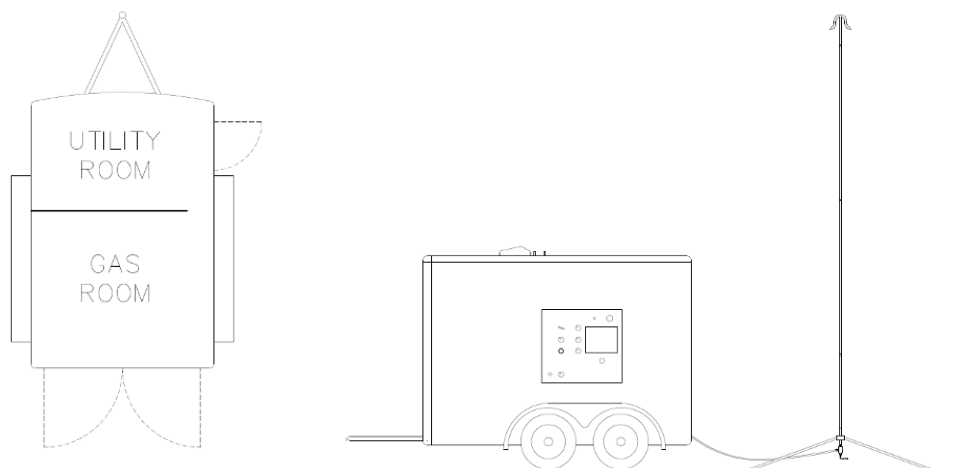


FIGURE 5 – HYDROGEN STATION EQUIPMENT LAYOUT

4 EQUIPMENT DESIGN & SAFETY

4.1 HAZARDOUS AREA CLASSIFICATION

Since hydrogen is unlikely to exist under normal operating conditions, it is therefore classified as Class 1 Division 2 hazardous area when hydrogen is present in the system. In addition, the trailer will be located near a hydrogen dispenser (also Class 1 Division 2 within 5 feet of the dispenser); all of the unclassified electrical equipment is installed in explosion-proof enclosures/boxes. Any electrical equipment outside of this box is intrinsically safe or rated for the environment.

For details on the extent of the classified area, see drawing PL-00742-02-01 in Appendix L.



Caution: No smoking, open flames, or use of electronic devices within the hazardous area of the HyStEP (~15ft).

4.2 MOBILITY & TRANSPORT

The HyStEP device is designed to be transported between hydrogen stations. All the equipment is located within a utility trailer which can be towed by a vehicle. The remote vent stack disassembles into several parts which are stowed inside the trailer for transport. The trailer is equipped with a dual axle torsional suspension system to minimize vibrations during transport.

The hydrogen system includes Quantum hydrogen tanks and the rack that houses the tanks has undergone an F.E.A. (Finite Element Analysis) to facilitate DOT (Department of Transportation) permitting of the trailer. DOT permitting is to be completed by the owner of the device.

4.3 HYDROGEN SYSTEM

The hydrogen system includes all the components shown on the simplified process and instrumentation diagram below.

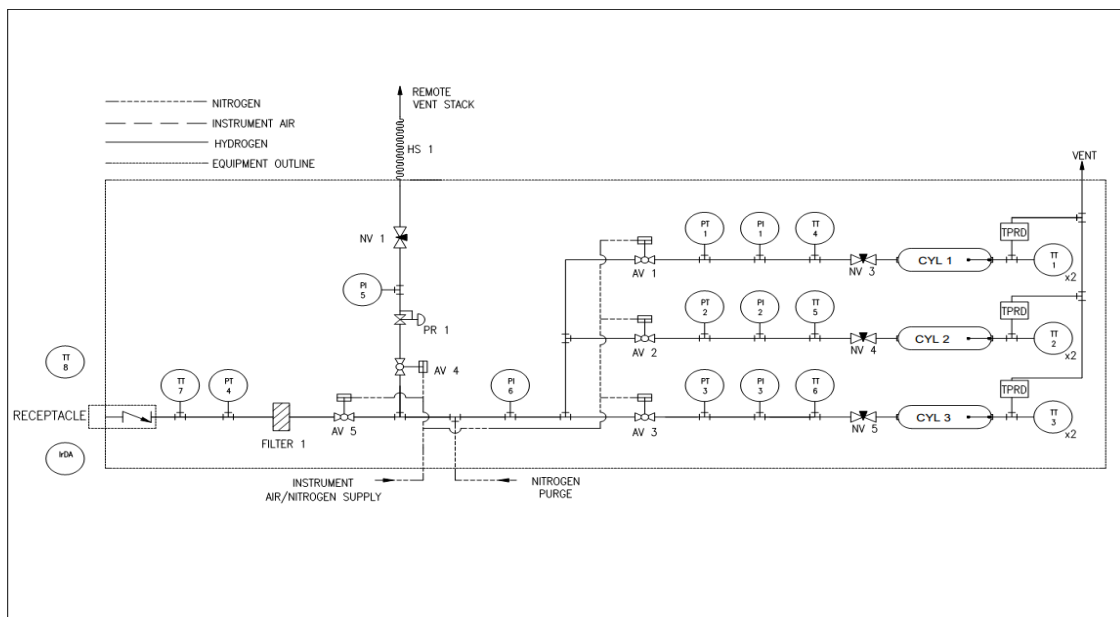


FIGURE 6 – SIMPLIFIED P&ID OF HYDROGEN SYSTEM

All the hydrogen components in the system are rated to a pressure of 87.5 MPa (12,690 psig) and a minimum temperature of -40°C (-40°F). For vibration resistance, cone and thread style fittings were primarily used. Pneumatically actuated valves (air valves) are of the needle valve style and manually operated needle valves were used as isolation valves on the tanks because there are no ball valves available with a -40°C temperature rating.



Note: All system piping is designed and built as per the requirements of ASME B31.12

4.4 HYDROGEN STORAGE SYSTEM

The storage system consists of 3 Quantum “Type 4” composite hydrogen storage tanks. The tanks are qualified in accordance with NGV2-2007 (R2012) and have a Luxfer thermal pressure relief device (TPRD) installed on each of them. Dual point thermocouples (22” long) are mounted inside the tanks to measure the temperature inside the tank at the tip of the thermocouple and 6” back from the tip. Figure 7 shows a photo of the end of the tank with the TPRD and in-line thermocouple. Figure 8 shows a photo of the inlet/outlet of the tank with the needle valve, thermocouple, pressure transducer, and pneumatically actuated needle valve.

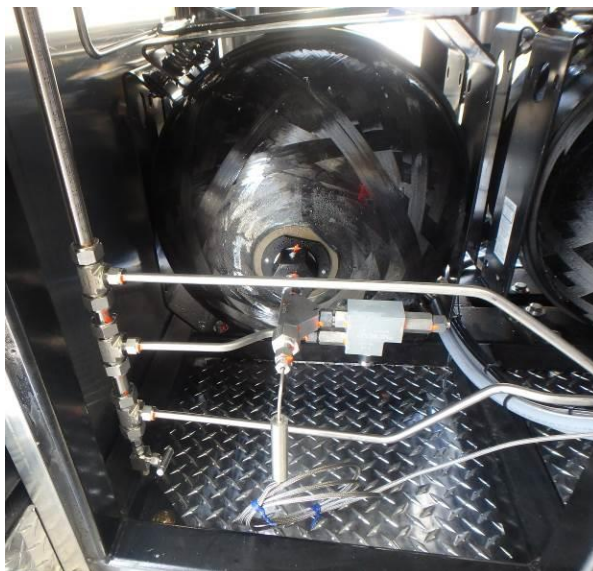


FIGURE 7 – HYDROGEN TANK TPRD AND IN-TANK THERMOCOUPLE

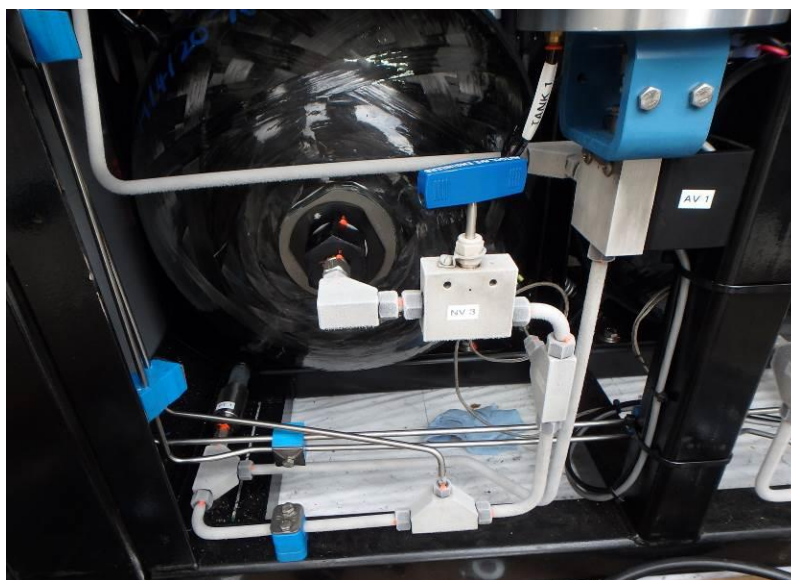


FIGURE 8 – HYDROGEN TANK INLET/OUTLET

Each tank has the specification shown in Table 4-1 below. The tanks are mounted using a Canimco “Profile A2” style bracket and a custom steel rack. More details on the mounting of the tanks are in Section 4.12 of this manual.

TABLE 4–1 – QUANTUM TANK SPECIFICATION

Part Number	116729
Quantity	3
ASM Weight	52 kg each (114.6 lb)
Internal Tank Volume at Service Pressure	76L each (2.68 cubic feet)

Capacity at 15°C and 70 MPa	3.1 kg (hydrogen)
Overall Length	718mm (28.27 inches)
Diameter	497mm (19.57 inches)
Service Pressure at 15°C	70 MPa (10,152 psi)
Operating Temperature Range	-40°C to +85°C (-40°F to +185°F)
Design Service Life	15 years or 5,000 fill cycles
Certification	Qualified in accordance with NGV2-2007 (R2012)

4.5 REMOTE VENT STACK SYSTEM

The remote vent stack is used for defueling the hydrogen system after testing or when the tanks are full. The vent stack has a tripod style base, CGA style outlet, and is 17'9" tall. It disassembles into 4 pieces which are stored in the trailer when not in use. The vent stack is connected to the trailer by a 50ft long hydrogen hose (two 25 ft. lengths with a coupling in the middle) allowing for it to be located in an appropriate location.

The hydrogen hose has a rating of 128.5 MPa (18,560 psig) and has quick connect fittings on either end of the hose. When in use, the hose is to be protected inside cable trays and traffic cones should be setup to close off the area where venting is occurring. Sand bags are also provided to place on the base of the vent stack to prevent it from being blown over in a strong wind.

Figure 9 shows the vent stack disassembled and inside the trailer for transportation (left) and assembled, ready for venting on the right.



Caution: Venting can be loud and potentially cause hearing damage. Ear plugs should be used when venting.



FIGURE 9 – REMOTE VENT STACK DISASSEMBLED (LEFT), SETUP FOR VENTING (RIGHT)

4.6 THERMAL PRESSURE RELIEF SYSTEM

On one end of each tank there is a Thermal Pressure Relief Device (see Figure 10) to vent the entire content of the tank in the event of a fire. The relief device used is a Luxfer PRD-700-02-0 with a MAWP of 87.5 MPa. From the outlet of each TPRD there is a 3/8" line that enters a 3/4" vent stack which exits the roof of the trailer. The top of the vent stack (see Figure 11) has a cap to prevent water from entering the stack. The bottom of the vent has a needle valve to drain any water out that may have entered the stack (if the cap has been removed).



Note: Check that TPRD vent cap is installed once per test site

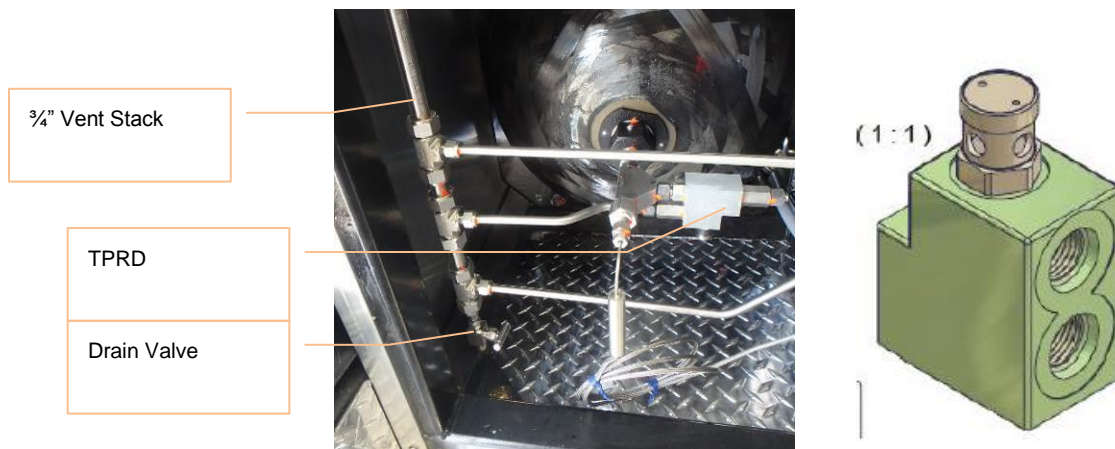


FIGURE 10 – TPRD VENT STACK (LEFT), SCHEMATIC OF TPRD (RIGHT)

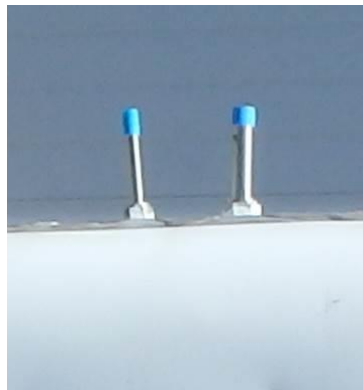


FIGURE 11 – VENT STACK CAPS

4.7 NITROGEN SYSTEM

4.7.1 Nitrogen Purge System

The nitrogen purge system is used for purging the hydrogen system prior to transport. The purge system has a MAWP of 3,000 psig and there is a rupture disk set at this pressure to ensure the system is not over pressurized in the event of high pressure hydrogen entering the system.

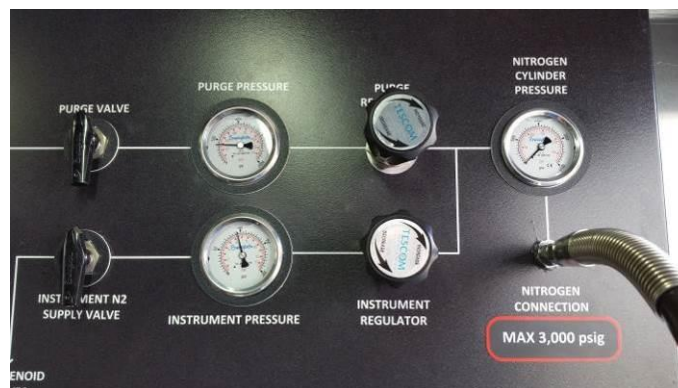
The purge system reduces the pressure from a nitrogen cylinder and controls the flow of gas into the hydrogen system. It includes the following components:

- Pressure reducing regulator (6000 psig inlet, 0-1,500 psig outlet)
- Pressure gauge (0 to 2,000 psi)
- Purge valve (ball valve)
- 2 micron particulate filter
- Purge flow control valve (needle valve with 15,000 psig rating)
- Check valve to prevent hydrogen flowing into nitrogen system (15,000 psig rated)
- Rupture disk with a 20 MPa (3,000 psig) rupture pressure, as a safety to prevent H₂ flow entering N₂ system if check valve and needle valve fail

Figure 12, Figure 13, and Figure 14 show the layout and components in the nitrogen purge system. On the nitrogen panel, the purge system is in the top row and the instrument nitrogen supply is in the lower row.



FIGURE 12 – NITROGEN SYSTEM

**FIGURE 13 – NITROGEN PANEL****FIGURE 14 – NITROGEN FILTER & FLOW CONTROL VALVE (LEFT), RUPTURE DISK (RIGHT)**

4.7.2 Instrument Nitrogen Supply

The instrument nitrogen system is used to supply pressurized nitrogen gas to the pneumatically actuated valves (air valves) in the hydrogen system. The system reduces the pressure from a nitrogen cylinder to approx. 95 psig using a pressure regulator. Then it is supplied to solenoid valves in the main control panel and distributed to the pneumatically actuated valves. There is also a valve override panel (see Figure 16) which bypasses the solenoid valves with manual 3-way ball valves. This is to be used in the event of a power loss or solenoid malfunction.

Components in the instrument nitrogen system include:

- Pressure gauge (0-200 psi)
- Pressure reducing regulator (3,500 psi inlet, 0 to 100 psi outlet)
- Ball valve
- Safety relief valve set at 125 psi
- Solenoid valves (inside explosion proof box)
- Pressure Switch
- Pneumatically actuated needle valves (for Hydrogen system)

- 3-way valves inside valve over-ride box



FIGURE 15 – INSTRUMENT NITROGEN SAFETY RELIEF VALVE



FIGURE 16 – VALVE OVERRIDE PANEL

4.8 ELECTRICAL SYSTEM

The HyStEP Device electrical system is made up of the sensors and instruments used to measure hydrogen temperature and pressure at various locations, the data acquisition and control system, the IR communications hardware, and the network hardware. This system includes a Class 1, Division 2 Hazardous Area Classification design.

The entire electrical system is powered by plugging the 80ft extension cord to a regular 120VAC/15A outlet at the site/facility where the HyStEP will be used. Ground Fault Circuit Interrupter (GFCI) circuit is required when used outside or in wet location.

The electrical cord is wired to the inside of explosion-proof enclosure to power the IrDA generator, the Main Solenoid Valve, and three DC power supplies as shown Figure 17. Each circuit is fused to protect the components. Electrical wiring details are included in the HyStEP Electrical As-built Package.

4.8.1 Explosion-Proof Enclosure & Intrinsic Safety

Explosion-proof enclosure and junction boxes are used to house unclassified electrical devices and connections. Intrinsic safety wiring is used to limit the energy delivered to the

electrical sensors and switches installed in hazardous locations. Intrinsic Safety Barriers are used for all pressure transducers, thermocouples, and switches.



Caution: The trailer **MUST** be bonded to a grounding source onsite when hydrogen is present in the system.

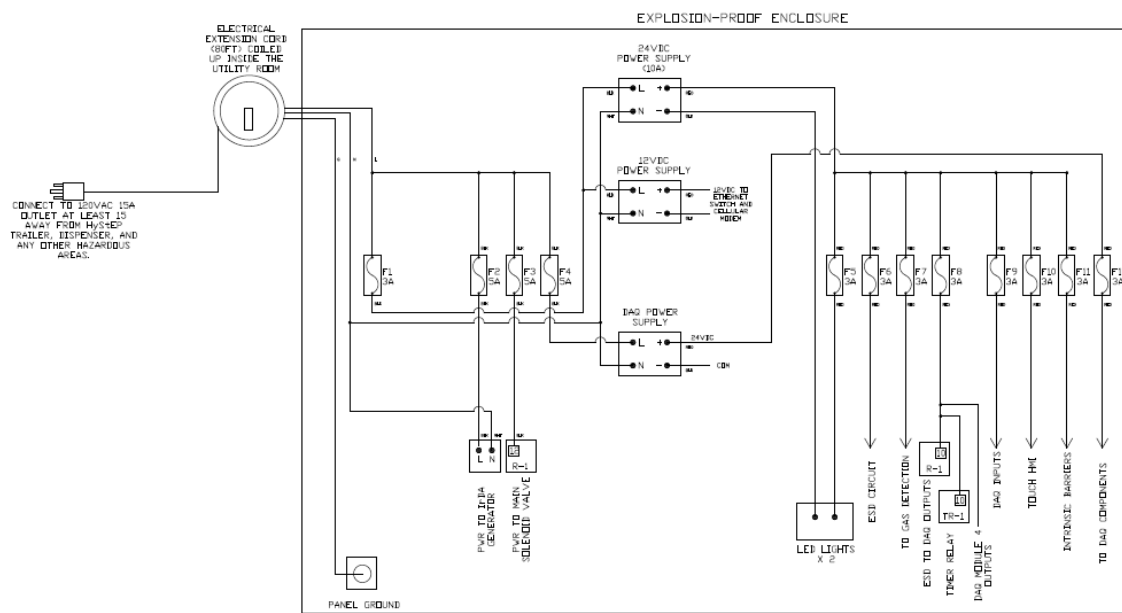


FIGURE 17 – HyStEP ELECTRICAL POWER DISTRIBUTION



Note: The HyStEP electrical system is separate from the trailer 12VDC system that is powered by the tow vehicle.

4.8.2 Emergency shut Down (ESD) Circuit

The emergency shutdown control circuit is the primary safety system for the HyStEP Device and was designed to reliably put the system in a safe state when any one of a number of triggers are activated. The circuit consists of seven separate relays that are each opened by a unique event. The relays include the ESD button, a cDAQ-controlled relay, the two heat sensors, the high alarm on the two H₂ detectors, and a failure of the H₂ detector in the rear of the trailer. The cDAQ controlled relays will open based on the alarms discussed in the previous section. Note that there is redundancy for H₂ detection since each detector has a hardwired relay as well as the cDAQ alarm to de-energize the ESD circuit.

When the ESD circuit is opened, the primary action is to close all of the pneumatic valves to shut off hydrogen flow into or out of the tanks, the main hydrogen manifold and the vent line. This is done in two ways. Firstly, the main solenoid valve is closed which shuts off nitrogen pressure to the solenoid manifold. Secondly, power to the individual solenoid valves is

removed which closes any that are open. These two actions prevent nitrogen pressure from reaching the pneumatic valves which are normally closed valves. Activating the shutdown by any of the relays will also activate the audible and visual alarms

4.8.3 Hydrogen Gas Detection

There are two hydrogen sensors installed inside the HyStEP trailer to monitor the hydrogen level in %LEL. One is in the Gas Room and one is in the Utility Room as a redundancy as the rooms are open to each other. The hydrogen sensor is attached to an explosion-proof enclosure where the transmitter and LED display are located. Real-time readings of hydrogen level can be read from the LED display through the glass front of the explosion-proof enclosure.

Each hydrogen sensor is hard-wired to the ESD circuit to shut down the ESD circuit when 25% LEL is detected or if the probe in the Gas Room fails. It also provides analog signals of the %LEL to the cDAQ controller.

4.8.4 Heat Detection

There are two heat detectors installed inside the HyStEP trailer to monitor fire hazards. One is in the Gas Room and one is in the Utility Room. The sensor is attached to an explosion-proof enclosure and activated when the sensor reach 65°C. Each heat detector is hard-wired to the ESD circuit to shut down the ESD circuit.

4.9 CONTROLS & DATA ACQUISITION SYSTEM

The HyStEP Device data acquisition and control system uses chassis-based National Instruments® CompactDAQ (cDAQ) hardware housed in the Explosion-Proof Enclosure.

Instrumentation on the HyStEP Device consists of position switches, solenoid valves, pressure switches, thermocouples, pressure transducers, and analog pressure gauges. The temperature sensors and pressure transducers are all connected to the data acquisition system.

The cDAQ can be connected to a network for data transfer or remote access in two ways. The system includes an Ethernet switch and jack with a CAT-5 cable so that an external computer can connect directly to the cDAQ local network.

The HyStEP Device control system consists of the control software which is written using National Instruments® LabVIEW to provide graphical user interface on the touchscreen monitor mounted on the Operator Panel to perform three modes of operation: Fueling Test, Defueling, and Purging.

4.9.1 cDAQ Alarm

Based on the FMECA and design reviews, a set of alarm conditions were defined that would require action from the HyStEP Device safety system. A matrix of these alarms was assembled that lists the sensor, the fault, the setpoint, the action taken and the conditions to reset the alarm. This matrix was then implemented in the LabVIEW software. One-hundred and twenty-three fault conditions are defined in this alarm matrix, although not all of them produce alarm notifications and/or system shutdown. For example, each pressure and

temperature sensor has six fault conditions: high alarm, high warning, low warning, low alarm, wiring fault 1, and wiring fault 2. For most of the sensors, only the high and low alarm conditions produce an action other than a warning message. The actions that can be taken include a screen notification with or without requiring an acknowledgement, an Abort command issued through the IrDA system, ESD circuit activation which closes all of the pneumatic valves, audible alarm activation, and visual alarm activation.

In addition to the warnings and alarms, there is a set of software safeguards that prevent the tank valves from opening in an unsafe condition. The condition that these safeguards prevent is opening one tank while one or more other tanks are open when the pressures in the tanks are significantly different. The result would be a high flow of gas from the higher pressure tank(s) to the lower pressure tank which could heat the lower pressure tank and cool the higher pressure tank(s) to temperatures that exceed the safety limits. These safeguards check the pressures of each tank with respect to the other two tanks to determine if it is safe to open the tank valve. If the difference in pressure to another open tank is greater than a predefined setpoint, the tank valve will not open. The default setpoint is 2 MPa.



Note: Refer to Alarm Matrix and Electrical Drawings for details in safety wirings and alarm details.

4.10 IrDA SAE J2799 COMMUNICATION

The infrared communications system was developed by IRDI Systems. The system includes an IrDA test signal generator with Modbus communication to the cDAQ CPU and an IrDA transmitter that is mounted next to the receptacle on the operator's panel. The signal generator produces the appropriate signal based on the SAE J2799 communication protocol using input from the cDAQ. The signal is then sent to the transmitter which is a Class 1 Division 2 rated device. A receiver on the dispenser nozzle reads the transmitted signal during fueling.



FIGURE 18 – IrDA GENERATOR (LEFT) & IrDA TRANSMITTER (RIGHT)

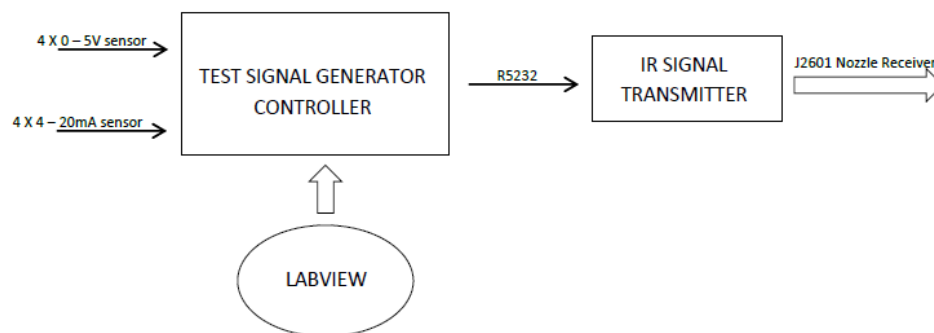
TABLE 4-2 – IRDA MANUFACTURER SPECIFICATIONS

The IR transmitter takes RS232 input signal and converts into return to zero J2799 format. It transmits the signal in J2799 infrared format.

Specification description	Value	Unit	Remarks
Signal input			
Format	RS232		NRZ
Power input			
Voltage (typ)	5	V	
Voltage (min)	3.5	V	
Current (typ)	140	mA	
Current (peak)	200	mA	
Absolute maximum			
Power voltage in	16	V	
Data voltage	+/- 25	V	
Signal output			
Format	J2799 Infrared		
Peak wavelength	890	nm	
Angle of transmit	+/- 60	Degrees	
Form factor	Rectangular		
Length	76	mm	
Width	33	mm	
Height	12	mm	
Weight	60	g	
Housing material	Delrin or POM		
Operation temperature	-40 to 80C		
Ingress protection	IP66		
Certification	None		
Output connector type	DB 15M		
Pin out			7 Gnd; 2 TXD; 1 +5V

Summary Specification

Test Signal Generation	
Communications	Front end: SAE J2601 transmit Back End: sensor input 4 X 0- 5V; 4 X 4 – 20mA
Power Supply:	5V – IR Transmitter Test signal controller: 100 – 240VAC
Physical Packaging	
Operating Temperature	-10C – 45C

**FIGURE 19 – IRDA SYSTEM SCHEMATIC**

The IrDA tab is used for many of the fault detection and communication tests. As shown in Figure 20, this tab allows the operator to override the IrDA signal on-the-fly. When the override button is activated the operator can manually enter values for each of the IrDA data fields which include the version number (VN), the receptacle type (RT), the tank volume

(TV), the fueling command (FC), the measured tank pressure (MP), and the measured tank temperature (MT). For general and communication fault tests, these values can be set to values outside of the acceptable ranges to check that the dispenser does not fuel. An additional feature of the IrDA tab is the corrupt buttons. The CRC Corrupt button will introduce an erroneous Cyclic Redundancy Check (CRC) string into the communications signal to check that the dispenser responds correctly to this fault condition. The Corrupt buttons for each data field will send an invalid parameter for that specific field (Invalid as per SAE J2799). Table 4-3 shows a list of the invalid parameters that will be sent, sequentially each time the corrupt button that specific data field is selected.

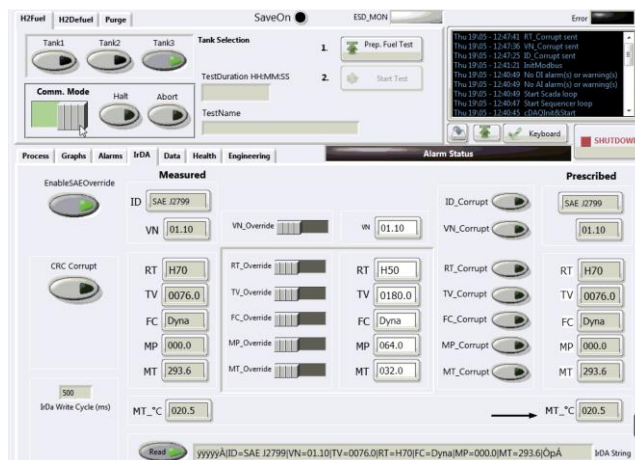


FIGURE 20 – TOUCHSCREEN CONTROL PANEL SHOWING THE IRDA TAB

TABLE 4-3 – LIST OF PREDETERMINED INVALID PARAMETERS

Data	J2799 Tag	Proper Data Value (in-range)	Predetermined Invalid Parameters
Protocol Identifier	ID=	SAE_2799	1. SAE_2799 2. SEA_2799 3. SAE_2979 4. SAE_2799 5. SAE_2799
Data Communications Software Version Number	VN=	00.00-99.99	1. 100.0 2. 99.9 3. #0.01 4. 00.0 5. 99.00
Tank Volume	TV=	0000.0 – 5000.0	1. 6000.0 2. 250.0 3. #250.0 4. 3500.0 5. 5000.1
Receptacle Type	RT=	H25, H35, H50, H70	1. H25 2. H35 3. H50 4. H70 5. h70
Fueling Command	FC=	Dyna, Stat, Halt, Abort	1. Dyna1 2. Boart 3. S-tat 4. Hal t 5. abort
Measured Pressure	MP=	000.0-100.0	1. 100.1 2. 100. (100.space) 3. #00.0 4. 00.0 5. O00.0
Measured Temperature	MT=	16.0-425.0	1. 425.1 2. 15.9space 3. 3#0.0 4. 2.73. 5. 290.0

All parameters are to be sequentially cycled through (1, 2, 3, 4, 5,...)

4.11 FAILURE MODES, EFFECTS, CRITICALITY ANALYSIS

Safety was the foremost goal of the HyStEP Device design and a significant effort was put into the safety analyses and the design and validation of the safety systems. Safety analyses included a detailed Failure Modes Effects and Criticality Analysis (FMECA) as well as a review of the design by the Hydrogen Safety Panel. The safety system design for the HyStEP Device is built upon an extensive alarm matrix which defines the various alarm triggers, responses and resets conditions. Significant alarms will trip the ESD circuit which puts the system in a safe state. These alarms were extensively tested and validated at Powertech and during testing at NREL.

FMECA

A brief summary of the HyStEP Device FMECA will be provided here. A detailed report including the FMECA worksheet can be found on the HyStEP website [13]. The FMECA was carried out once the Project Team and Powertech had developed a detailed P&ID and a comprehensive list of the system components, specifications, suppliers and part numbers. The overall HyStEP Device design, including the P&ID, electrical diagrams and component lists, was then analyzed in a detailed FMECA facilitated by Intertek Consulting. The results of the FMECA are summarized as follows:

- 7 functional blocks were analyzed
- 44 functions were defined
- 202 failure modes and effects were identified
- Each effect was assigned severity, occurrence, and detection/prevention ratings
- 47 failure mode effects had severity of 9 or 10 indicating a safety hazard
- 20 failure mode effects had a Risk Priority Number ($RPN = \text{severity} * \text{occurrence} * \text{detection}$) greater than 100

Following the completion of the FMECA, Powertech and the Project Team addressed all failure mode effects with RPN values > 100 and severity of 9 or 10. Actions were taken to mitigate these risks through design changes, safeguards, and/or operating procedures.

4.12 HYDROGEN TANK STRUCTURAL FRAME & MOUNTING

The tank-mounting frame assembly shown in Figure 21 safely secures and houses the high-pressure tanks, explosion proof box, operator panel, components, and plumbing. The “Profile A2” style Canimco mounting brackets were used to securely hold the tanks to the steel structural frame while the springs in the Canimco brackets allow for expansion of the cylinder while pressurized (see Figure 22). The frame was designed to attach to the trailer frame using 6 bolts. These portions of the trailer frame were further supported using steel box tubing. The entire assembly was designed to withstand acceleration loads of 8g in each of the principal directions. A finite element stress analysis (FEA) was performed on the frame as modeled in Figure 23 to verify these loads. FEA analysis was conducted in a manner to accommodate certification of the trailer to DOT SP-13173.



FIGURE 21 – HYDROGEN AND NITROGEN FRAME PRIOR TO TANK INSTALLATION (LEFT), AFTER TANK INSTALLATION (RIGHT)

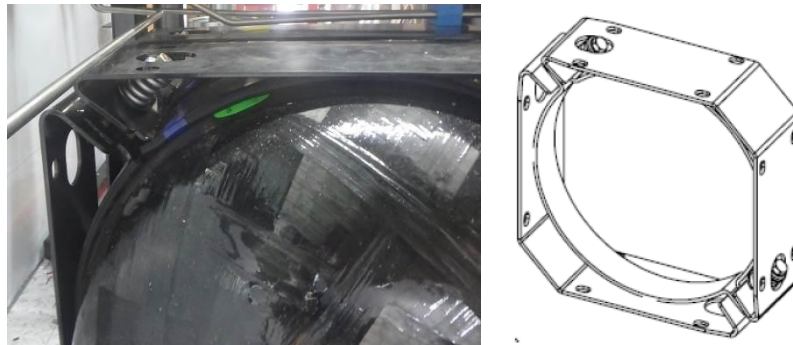


FIGURE 22 – CANIMCO MOUNTING BRACKET

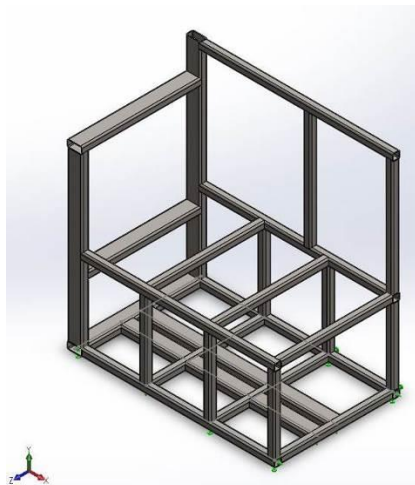


FIGURE 23 – STRUCTURAL FRAME USED IN F.E.A.

5 cDAQ CONTROL SYSTEM

5.1 PROGRAMMABLE LOGIC CONTROLLER (cDAQ)

The HyStEP Device data acquisition and control system uses chassis-based National Instruments® CompactDAQ (cDAQ) hardware. The system includes a CPU module (NI cDAQ 9132), one 16-channel analog module (NI9208), one 16-channel thermocouple module (NI9213), one 32-channel digital input/output module (NI9375), and a 24 VDC power supply (NI PS-16). The cDAQ system is installed inside the explosion-proof electrical enclosure in the Gas Room as shown in Figure 24.



Note: Refer to the electrical drawings for layout and wiring details and Bill of Materials for component details.

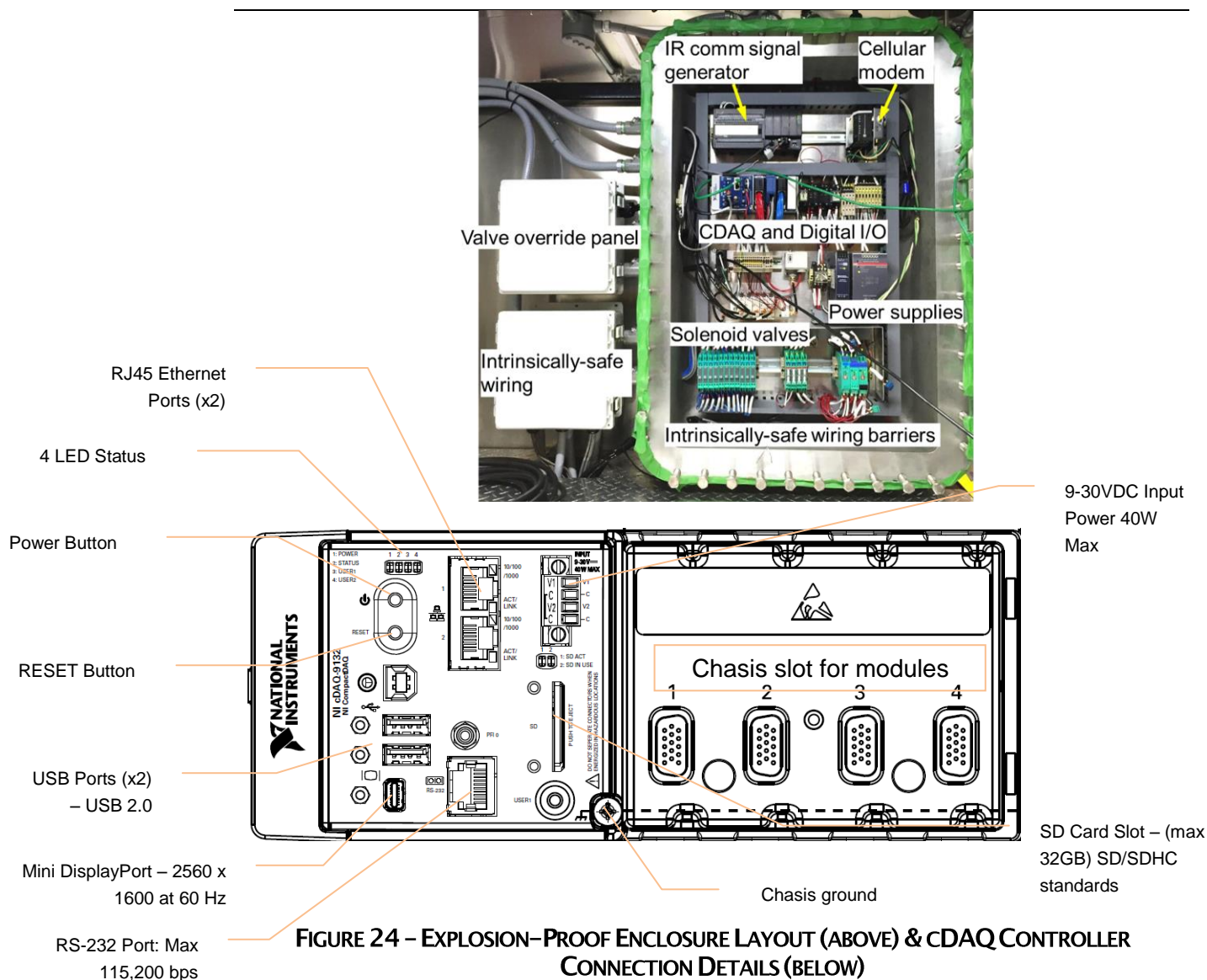


FIGURE 24 – EXPLOSION-PROOF ENCLOSURE LAYOUT (ABOVE) & CDAQ CONTROLLER CONNECTION DETAILS (BELOW)

Below is a summary of the general operating/storage conditions and operators shall refer to the complete manufacturer specifications and user manuals for other operating conditions, safety, and hazards at <http://www.ni.com>



Note: Bolts on the explosion proof enclosure are to be torqued to 65 ft.-lbs

TABLE 5-1 – cDAQ OPERATING CONDITIONS

	NI cDAQ 9132	NI 9208	NI 9213	NI 9375	NI PS-16
Operating Environmental Conditions	-20 to 55 °C 10 to 90% RH, noncondensing	-40 to 70 °C 10 to 95% RH, noncondensing	-40 to 70 °C 10 to 95% RH, noncondensing	-40 to 70 °C 10 to 95% RH, noncondensing	-25 to 70 °C
Storage Environmental Conditions	-40 to 85 °C 5 to 95% RH, noncondensing	-40 to 85 °C 5 to 95% RH, noncondensing	-40 to 85 °C 5 to 95% RH, noncondensing	-40 to 85 °C 5 to 95% RH, noncondensing	n/a
Maximum Altitude	5,000 m	2,000 m	2,000 m	2,000 m	n/a
Operating Vibration	Random – 5 g _{rms} , 10 to 500Hz Sinusoidal – 6 g, 10 to 500 Hz	Random – 5 g _{rms} , 10 to 500Hz Sinusoidal – 5 g, 10 to 500 Hz	Random – 5 g _{rms} , 10 to 500Hz Sinusoidal – 5 g, 10 to 500 Hz	Random – 5 g _{rms} , 10 to 500Hz Sinusoidal – 5 g, 10 to 500 Hz	n/a
Operating Shock	30 g, 11 ms half time, 50 g, 3 ms half time, 18 shocks at 6 orientations	30 g, 11 ms half time, 50 g, 3 ms half time, 18 shocks at 6 orientations	30 g, 11 ms half time, 50 g, 3 ms half time, 18 shocks at 6 orientations	30 g, 11 ms half time, 50 g, 3 ms half time, 18 shocks at 6 orientations	n/a
Hazardous Locations (UL)	Class I, Division 2, Groups A, B, C, D, T4: Class I, Zone 2, AEx nA IIC T4	Class I, Division 2, Groups A, B, C, D, T4: Class I, Zone 2, AEx nA IIC T4	Class I, Division 2, Groups A, B, C, D, T4: Class I, Zone 2, AEx nA IIC T4	Class I, Division 2, Groups A, B, C, D, T4: Class I, Zone 2, AEx nA IIC T4	n/a



Note: The cDAQ system will start automatically when the trailer is connected to 120VAC electrical power (refer to cDAQ Touchscreen Operation for interfacing with cDAQ).

The cDAQ features 4 LEDs – POWER, STATUS, USER1, and USER2 and the table below lists the LEDs and status indications.

TABLE 5–2 – cDAQ LED STATUS INDICATIONS

LED	LED Color	LED State	Indication
POWER	Green	Solid	The cDAQ controller is powered from the V1 input.
	Yellow	Solid	The cDAQ controller is powered from the V2 input.
	—	Off	The controller is not powered.
STATUS	Yellow	2 flashes every few seconds	The controller has detected an error in its software. This usually occurs when an attempt to upgrade the software is interrupted. Refer to the <i>Measurement & Automation Explorer Help</i> for information about installing software on the controller.
		3 flashes every few seconds	The controller is in safe mode. Refer to the <i>Measurement & Automation Explorer Help</i> for information about safe mode.
		4 flashes every few seconds	The software has crashed twice without rebooting or cycling power between crashes. This usually occurs when the controller runs out of memory. Review your RT VI and check the memory usage. Modify the VI as necessary to solve the memory usage issue.
		Continuously flashing	The controller either booted into an unsupported operating system, was interrupted during the boot process, or detected an unrecoverable software error.
		Solid	The controller is booting up.
	Red	Continuously flashing	An internal power supply has failed. Check front-panel I/O and C Series module connections for shorts. Remove any shorts and power cycle the controller. If the problem persists, contact National Instruments.
	—	Off	Normal operation.
USER1, USER2	Green/yellow	—	<p>USER LEDs are controlled directly from your application. You can define the USER1 and USER2 LEDs to meet the needs of your application. You can use the system hardware property node from the NI System Configuration API to write a state to the USER LEDs.</p> <p>(NI cDAQ-9132/9133/9134/9135 for LabVIEW Real-Time) You can also define a USER LED in LabVIEW Real-Time by using the RT LEDs VI. For more information about the RT LEDs VI, refer to the <i>LabVIEW Help</i>.</p>

5.2 HUMAN-MACHINE INTERFACES (HMI)

The control software for the HyStEP Device was developed using LabVIEW. National Instruments hardware and software were chosen for their ease of integration, widespread availability and use, and ease of modification. The graphical user interface, which is accessed via the touchscreen panel, consists of a series of screens that allow the user to carry out fault detection, communications, and fill tests as defined in CSA HGV 4.3. Figure 25 shows the touchscreen panel mounted on the Operator Panel and Figure 26 shows the back of the touchscreen panel and its connections & buttons.



FIGURE 25 – HUMAN-MACHINE INTERFACE ON OPERATOR PANEL



FIGURE 26 – BACK OF THE TOUCHSCREEN PANEL FROM THE GAS ROOM



Note: Refer to the electrical drawings for layout and wiring details and Bill of Materials for component details.

5.3 NETWORKING & REMOTE ACCESS

The cDAQ can be connected to a network for data transfer or remote access in two ways. The system includes an Ethernet switch (Figure 27) and a CAT-5 jack (see Figure 28) so that an external computer can connect directly to the cDAQ local network. This allows for data transfer to a laptop in the field, for instance. In addition, a cellular modem and antenna are also connected to the Ethernet switch. The cellular modem provides for a wireless internet connection for remote access.



FIGURE 27 –ETHERNET SWITCH AND CELLULAR MODEM

To access the HyStEP local area network, connect the laptop computer to the CAT-5 jack in the Utility Room via a straight-thru CAT-5 cable as shown in Figure 28.



FIGURE 28 –CAT–5 JACK TO CONNECT TO THE HYSTEP LOCAL AREA NETWORK

Open the “Network” view in Windows to look for a computer name “H2_TestStation”, which is the cDAQ Controller as shown in Figure 29.

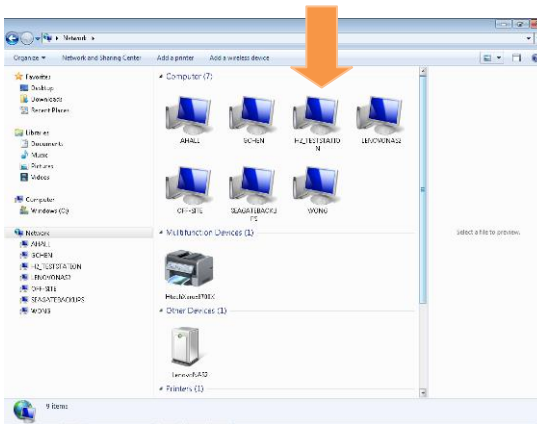
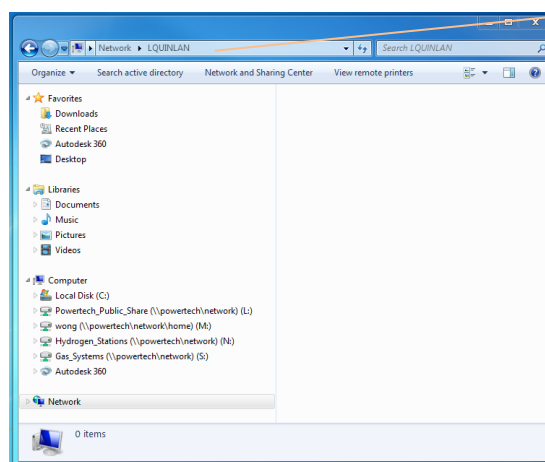
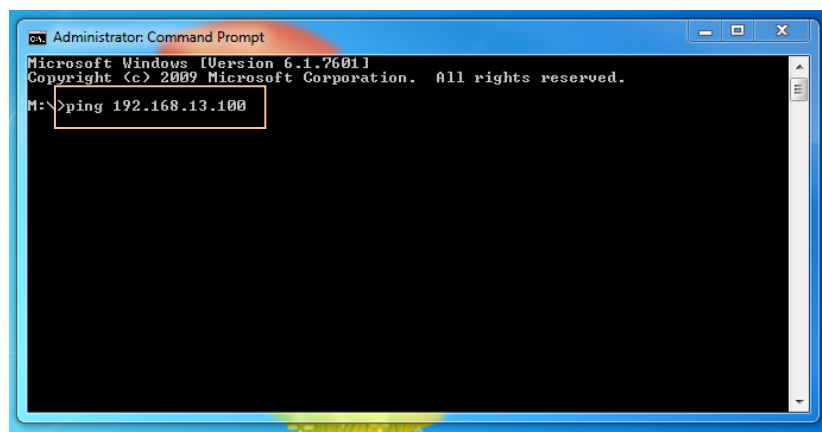


FIGURE 29 – WINDOWS NETWORK VIEW WHEN CONNECTED TO HYSTEP LAN

If unable to see the HyStEP computer “H2_TestStation” while connected to local area network, launch the Windows Command Prompt, in the command prompt, type “Ping 192.168.13.100” and press Enter to see if your laptop can see the cDAQ computer. If so, open a Windows Explorer and type \\192.168.13.100 in the address bar to see the data folders.



Type \\192.168.13.100 and press Enter.

FIGURE 30 – WINDOWS COMMAND PROMPT (ABOVE) & WINDOWS EXPLORER (BELOW)

5.4 OPERATOR CONTROL PANEL

As shown in Figure 31, the Operator Panel located on the side of the trailer consists of the AV alarm, Silence Button, HMI touchscreen, ESD Button, hydrogen receptacle, IrDA transmitter, and a simplified schematic of the hydrogen system fitted with pressure gauges, valve, and pressure regulator.



FIGURE 31 – OPERATOR PANEL

5.5 NITROGEN PURGE & PNEUMATIC CONTROL PANEL

The nitrogen purge and pneumatic control panel can be assessed from the back of the trailer. It diverts nitrogen supply to two sub-systems: Purge and Instrument Control. Figure 32 shows the control panel layout and its control components.



FIGURE 32 – NITROGEN PURGE & INSTRUMENT CONTROL PANEL LAYOUT

5.6 PNEUMATIC VALVE OVERRIDE PANEL

The operator-bypass valve override is located inside a lockable box by the Explosion-proof enclosure as shown in Figure 33. It allows the operator to manually override the pneumatic valves to either “Open or Close” position individually.



Caution: cDAQ will no longer be able to control the pneumatic valves when the 3-way valve is turned to positions other than “Normal”. The override is provided for the operator to bring the HyStEP to safe conditions when components fail such as solenoid valves or cDAQ digital output module. For example, cDAQ is not able to defuel the tanks due to failed solenoid valves. Then the operator can override the corresponding valves to either “open or close” position to defuel the tanks in a safe manner.

The 3-way valve is located upstream of the cDAQ solenoid valve that sends nitrogen to the solenoid valve, to the pneumatic valve directly, or to shut-off according to its position as shown in Figure 32.

When the valve handle is pointing

Upwards, it is the default “Normal” position that cDAQ can control the pneumatic valve.

Right, it is the “Closed” position that the pneumatic valve is closed

Down it is the “Open” position that the pneumatic valve will remain open as long as nitrogen supply is available.



Caution: Only trained & experienced personnel shall use this override. The box shall remain locked at all time.



Caution: Check the system pressure before overriding valves. Do not open valves if pressure differential between tanks greater than 2 MPa or not known.

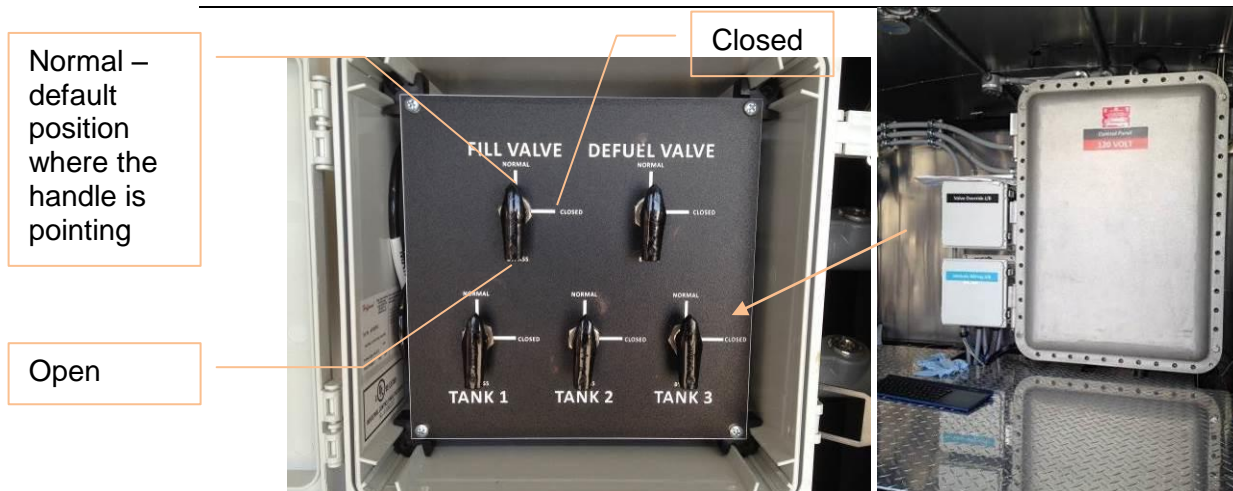


FIGURE 33 – INSTRUMENT VALVE OVERRIDE PANEL LOCATION (RIGHT) & INSIDE LAYOUT (LEFT)

6 SETTING UP THE HYSTEP

6.1 ARRIVING ONSITE

Upon arriving on-site to a new station, the operator should evaluate the site suitability and safety by following the steps below:

1. Identify the locations of the hydrogen dispenser to be tested and check the surrounding for clearance
2. Evaluate the site for the safest location for setting up the remote vent stack.
3. Use traffic cones to secure the areas.
4. Locate your 120VAC electrical power outlet (a total length of 80 feet electrical cord) and at least 15' away from trailer
5. Locate your grounding point
6. Check the nitrogen supply
7. If all of the above is satisfied, proceed to the next section; otherwise, do not operate the HyStEP and contact the dispenser owner for resolutions and/or further instructions.

This will help determine the area that will need to be closed off and optimize time onsite.



FIGURE 34 – HYSTEP DEVICE ARRIVING AT FUELING STATION

6.1.1 Positioning the Trailer

When pulling up to a station ensure that:

1. There is enough room to open operator panel door without hitting anything
2. Check that the receptacle inside the operator panel is close enough to the dispenser for the nozzle to reach. Since the receptacle is on the left hand side of the panel, it is better to have the panel door slightly back from the dispenser so the hose is not in the way while using the operator panel.

3. Ensure the grounding cable can reach a grounding point
4. Check that the electrical cable can reach an electrical outlet that is located outside of the stations hazardous area
5. Make sure that there is a safe location for venting gas within 50 feet of the back end of the trailer. A safe location for venting gas requires:
 - a. No ignition sources or unclassified electrical equipment within 15 feet of the remote vent stack outlet (see drawing PL-00742-02-01 for more detail)
 - b. No canopy or object that could trap gas above the vent outlet within the hazardous area
 - c. Vent stack is not located in a high traffic area as area around the stack will have to be coned off from general public.



FIGURE 35 – POSITIONING TRAILER AT A STATION

6.1.2 Securing the Trailer

Once the trailer is positioned in front of the dispenser, it must be secured to prevent motion. This is done by:

1. Place wheel chocks on both sides of tires to prevent wheels from rolling



FIGURE 36 – WHEEL CHOCKS

2. Lower supports on rear end of trailer



FIGURE 37 – LOWERING TRAILER SUPPORT

3. Disconnect the electrical plug on the trailer from the plug on the tow vehicle



FIGURE 38 – REMOVE TRAILER ELECTRICAL CONNECTION FROM TOW VEHICLE



Caution: Trailers 12VDC electrical is not rated for Class 1 Div. 2 locations, ensure electrical connection is unplugged from the tow vehicle prior to testing

4. If desired, unhitch trailer by:
 - a. Disconnecting safety chains and emergency brake cable
 - b. Remove the coupler locking device (pin) and release the coupler-locking device (raise the lever)
 - c. Use the jack to raise the coupler high enough for the hitch ball to slip beneath (see Figure 39)



FIGURE 39 – USING THE JACK TO UNHITCH THE TRAILER

- d. Verify that the trailer is free from the tow vehicle
 - e. Drive the tow vehicle forward, away from the device
 - f. Lower the jack until the trailer is level
5. Open the rear doors of the trailer and latch them open



Caution: Rear doors of trailer must remain open throughout testing to ensure proper ventilation of gas room. Doors are monitored by cDAQ and alarmed if doors are closed.



Danger: Doors may swing violently in the wind. Make sure to secure doors.

6.1.3 Grounding the Trailer

Locate the grounding point on-site. Connect the grounding cable from this to the trailer. The trailer has 2 grounding points, one forward from the operator's panel and one inside the back door by the nitrogen rack (see Figure 40). The grounding cable can be connected to either of these points. Grounding cables located inside the utility room can be joined together to reach the desired length.



FIGURE 40 – TRAILER GROUNDING POINTS

6.1.4 Pre-Startup Checklist

Before connecting electrical extension cord to the 120VAC power source, the operator shall perform the pre-startup checklist below.

1. Tow trailer to dispenser
2. Put wheel chocks on either side of wheels
3. Lower trailer supports at rear
4. Disconnect trailer electrical cable from the tow vehicles electrical plug
5. Unhitch trailer (if desired)

6. Open rear doors and latch open
7. Connect grounding cable to site ground
8. Connect other end of grounding cable to trailer to one of the 2 grounding points provided

6.2 SITE PREPARATION

6.2.1 Remote Vent Stack

The remote vent stack is to be setup in a safe location using the following procedure:

1. Close off venting area using traffic cones (see Figure 55)
2. Remove the vent stack sections from the trailer and put them in the coned area for assembly. Also bring the 2 wrenches labeled “Vent Stack”, the mallet and the mat from the tool chest.



FIGURE 41 – VENT STACK SECTIONS

3. Set-up section 1, the vent stack base by:
 - a. Loosening the red and silver nut on vent stack tubing
 - b. Slide the tubing down using light taps from the mallet (to make sure the bottom does not hit the ground when the legs are pull out in Step c)
 - c. Pull the legs of the tripod out until the supports are parallel with the ground (see Figure 42 right)



FIGURE 42 – VENT STACK SETUP: STANDING UP TRIPOD (LEFT) & LEGS FULLY OUT (RIGHT)

- d. Adjust the tubing so the bottom is just above the ground
- e. Tighten nut on bottom of tripod



FIGURE 43 – VENT STACK SETUP: TIGHTENING NUT ON BOTTOM OF TRIPOD

- f. Put sandbags on the base (see Section 6.2.6)
- g. Tighten the red and silver nut to set the position



FIGURE 44 – VENT STACK SETUP: TIGHTENING THE RED & SILVER NUT

4. Connect tubing sections 2 and 3 (straight 1” tubing) using the wrench and mat provided in the Tool Chest



Note: The mat is to protect the tubing, nut, and ferrule from physical damage against hard surface (not shown in photos)



FIGURE 45 – VENT STACK SETUP: CONNECTING SECTIONS 2 AND 3

5. Connect sections 3 & 4 of the vent stack in the same manner



FIGURE 46 – VENT STACK SETUP: CONNECTING SECTIONS 3 AND 4

6. Lift sections 2,3, and 4 so it is oriented vertically



FIGURE 47 – VENT STACK SETUP: LIFTING SECTIONS 2, 3 & 4 ONTO SECTION 1

7. Lift sections 2, 3, & 4 onto section 1 and tighten connection using wrench



FIGURE 48 – VENT STACK SETUP: CONNECTING SECTIONS 1 & 2 USING WRENCH

8. Close off area where vent hose is to be run, using traffic cones
9. Place cable trays on the ground for the desired hose run
10. Run the vent hose to desired venting location and place inside cable trays. **Pay particular attention to the coupling in the middle of the hose and ensure it is protected by the cable tray (see Figure 53 and Figure 54)**
11. Connect the vent hose to quick connect on the bottom of the vent stack
12. Connect the vent hose to the quick connect located by the nitrogen cylinder rack.



FIGURE 49 – VENT HOSE QUICK CONNECT IN BACK RIGHT SIDE OF TRAILER (LEFT), QUICK CONNECT ON VENT STACK (RIGHT)



Caution: The vent hose **MUST** be properly connected to the vent stack before its other end is connected to the trailer



Caution: The defuel valve located on the Operator Panel **MUST** be fully closed prior to the connection.



Caution: Check the connection to ensure its properly connected



Caution: Take care not to damage the quick connects on either end of the hose while setting up, inspect fitting for damage before each use

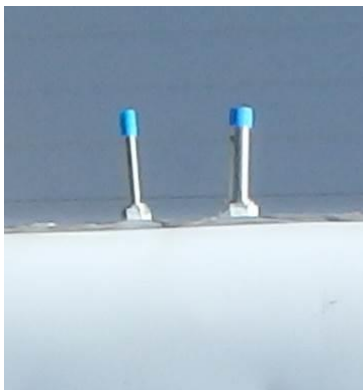
13. Place sandbags on base of vent stack (see Figure 56)
14. Place sandbags on the hose just before the connection point on both ends of hose (see Figure 56)
15. Vent stack is now ready to use



Danger: Make sure there is a sandbag on each end of the vent hose to prevent hose whip in the event of a connection failure or release

6.2.2 Trailer TPRD and Nitrogen System Vent Stacks

Check that caps are on vent stack. If one has been lost, refer to the maintenance section of this manual for further procedures. Spares can be found in the tool chest.

**FIGURE 50 – VENT STACK CAPS**

6.2.3 Nitrogen Source

Nitrogen must be supplied to the system for purging and to run the pneumatic control system. The HyStEP device has a rack that can store two nitrogen T or K cylinders. This can either be delivered to site or transported within the trailer. Another option is to use a nitrogen bulk pack delivered to site. There is a short hose nitrogen hose that can be used if the cylinders are mounted inside the trailer or a long hose if the cylinders are left outside the doors. Figure 51 shows the nitrogen rack with 2 “K cylinders” mounted in it.



Caution: Nitrogen hose has a minimum bend radius of 4”.



Caution: Always check that the connection on both ends of the nitrogen hose are tight and bleed valve is fully closed prior to opening nitrogen cylinder.

**FIGURE 51 – NITROGEN RACK**

6.2.3.1 Cylinder Installation/Removal

In order to install hydrogen cylinders, the following procedures should be followed:

1. Place nitrogen cylinder into the back of the trailer



Note: Nitrogen cylinders should be installed in the forward bracket before it is installed into the bracket located farther back in the trailer.

2. Open the top bracket by removing the screw on the joint
3. Remove the strap from the ratchet on the bottom bracket
4. Place the cylinder into position inside the “hoops” of the bracket
5. Wrap the ratchet strap around the cylinder on the bottom bracket
6. Tighten the strap around the cylinder using the ratchet. This will locate it within the top bracket as well
7. Close the top bracket and secure by tightening the bolt
8. Repeat steps 1-7 for the second cylinder

For cylinder removal follow these procedures in the reverse order.

6.2.4 Hose & Cable Trays

The hydrogen vent hose, electrical cord, and ground cord must be protected by a cable tray in any area with vehicle traffic or where it could pose a tripping hazard. Cable trays are stored inside the utility room and can be connected together to make a long line (see Figure 52 and Figure 53).

The hydrogen vent hose is stored in the utility room along with the electrical cable. When setting up the vent hose pay particular attention to ensure that the coupling in the middle of the hose is protected (see Figure 54).



FIGURE 52 – USING CABLE TRAYS TO PROTECT VENT HOSE FROM VEHICLE TRAFFIC



FIGURE 53 – INSTALLING CABLE TRAYS



FIGURE 54 – HYDROGEN VENT HOUSE COUPLER MUST BE PROTECTED INSIDE A CABLE TRAY

6.2.5 Cones

Safety cones are provided to identify the area around the vent stack, so drivers and pedestrians avoid the area. Cones should be used to close off the area that venting occurs in and any other areas around the trailer that must be closed for public.



FIGURE 55 – SAFETY CONES AROUND VENTING SYSTEM

6.2.6 Sand Bags

Sand bags are provided to weigh down the base of the vent stack. It is recommended to place 6 sandbags on the vent stack base and one on each ends of the hose (see Figure 56).



Danger: Make sure there is a sandbag on each end of the vent hose to prevent hose whip in the event of a connection failure or release



FIGURE 56 – SIX SANDBAGS ON VENT STACK BASE AND ONE ON HOSE END

6.3 EQUIPMENT PREPARATION

6.3.1 Preparing Pneumatic Control System

To prepare the pneumatic control system for use, follow the steps below:

1. Ensure the Nitrogen Purge and Instrument valves and regulators are closed

2. Connect nitrogen hose to the nitrogen inlet



Caution: Nitrogen tank **MUST** be below 3,000 psig, check prior to connecting.

3. Connect the Nitrogen tank to the hose using the wrench provided
4. Open the Nitrogen Tank Valve slightly, close it, and then open the nitrogen bleed valve to purge the hose. Repeat 3 times (see Figure 57)



FIGURE 57 – OPEN NITROGEN TANK VALVE (LEFT), NITROGEN BLEED VALVE (RIGHT)

5. Check that the nitrogen bleed valve is closed and open the tank valve
6. Adjust the Instrument N2 Regulator to a pressure of 95psi (see Figure 58)



FIGURE 58 – ADJUSTING INSTRUMENT REGULATOR TO 95 PSIG

7. Open the Instrument N2 Supply Valve (see Figure 59)

**FIGURE 59 – OPENING INSTRUMENT N2 SUPPLY VALVE**

8. Check that nitrogen pressure is still at 95psi, if not adjust regulator



Note: If pressure exceeds 95 psi, a pneumatic valve will have to be cycled to drop the pressure (regulator is not self-venting).



Caution: Nitrogen pneumatic supply monitored by a safety relief valve at 125 psi.

9. Instrument nitrogen system is now ready to use

6.3.2 Checking Manually Controlled Valves

Before using the device it is important to check that the manual valves are in the correct position. All the valves should be in the positions shown in Table 6-1.

TABLE 6-1 – VALVE POSITIONS PRIOR TO START-UP

Valve/Regulator	Position
Purge Regulator	Closed (Counter-clockwise to close)
Purge Valve	Closed (perpendicular to line)
Purge Flow Control Valve	Closed (Clockwise to close)
Tank 1 Isolation Valve (NV 3)	Open (Clockwise to close)
Tank 2 Isolation Valve (NV 4)	Open (Clockwise to close)
Tank 3 Isolation Valve (NV 5)	Open (Clockwise to close)
Defuel Valve	Closed (Clockwise to close)
Defuel Regulator	Closed (Counter-clockwise to close)

6.3.3 Prior to Power-Up

Before connecting the HyStEP device to electrical power, or conducting any test, the operator shall make sure the following steps are complete.

1. Tow trailer to dispenser
2. Put wheel chocks on either side of wheels
3. Lower trailer supports at rear
4. Connect grounding cable to site ground
5. Connect other end of grounding cable to trailer at one of the 2 grounding points provided
6. Open rear doors and latch open
7. Install nitrogen cylinder (if required)
8. Ensure the Nitrogen Purge and Instrument valves and regulators are closed
9. Connect the Nitrogen tank to the hose
10. Open the Nitrogen Tank Valve slightly, close it then open the nitrogen bleed valve to purge the hose. Repeat 3 times
11. Check that the nitrogen bleed valve is closed and open the tank valve
12. Adjust the Instrument N2 Regulator to a pressure of 95psi
13. Open the Instrument N2 Supply Valve
14. Check that nitrogen pressure is still at 95psi, if not adjust regulator
15. Check that needle valves on Hydrogen Tanks are fully open and that all valves are in the correct position (see Table 6-1)
16. HyStEP Device is now ready to power up

6.3.4 Electrical Power

Before removing the electrical cord from the trailer, locate a 120V/15A electrical outlet that is located outside of the hazardous area (5 ft. from the dispenser as per NFPA 2 or 15 ft. from the HyStEP device as per NFPA 70). Once an outlet has been located, place cable trays down on the ground in locations where the cord will have vehicle traffic or where it could pose a tripping hazard.

The electrical cord is stored in the utility room, coiled on a hook. When in use it is run through an electrical pass-thru to the right side of the door (see Figure 60). Pull the cable through the opening, and run it to the electrical outlet, placing it in the cable tray as required.

Immediately, once the cord is plugged in, the HyStEP device will power up. The cDAQ will start up, and lights will turn on. The visual alarm will flash until the HyStEP LabVIEW program has fully loaded.

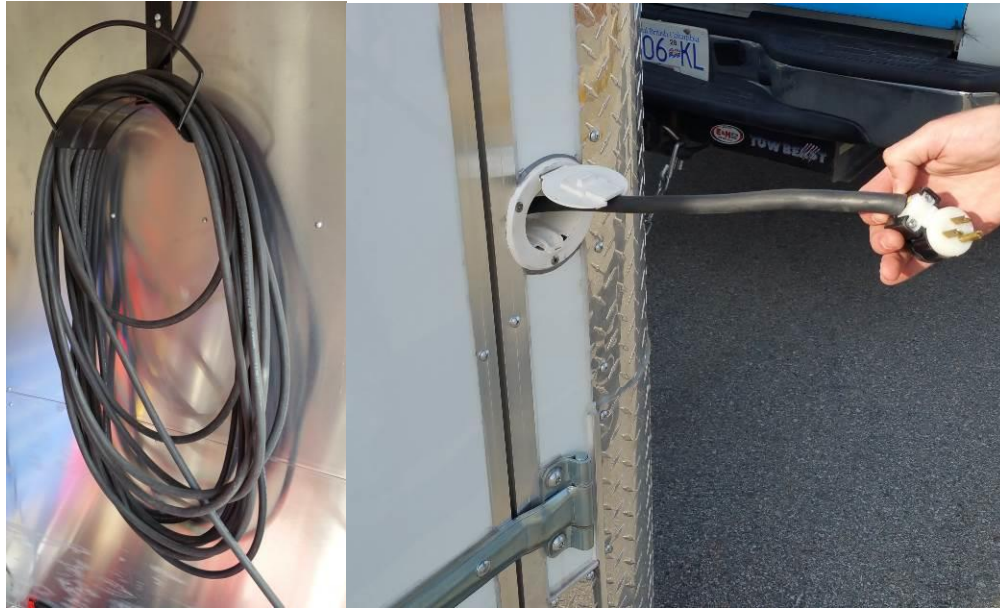


FIGURE 60 – ELECTRICAL CORD STOWED (LEFT), ELECTRICAL BULKHEAD (RIGHT)

6.3.5 Logging On to HMI

Once electrical power is supplied to the trailer, the cDAQ will automatically turn on and the Windows logon screen will be seen on the touchscreen.

6.3.6 Checking System Alarms & Parameters

Typically when the system starts up, an alarm may be present. These can be acknowledged by selecting the alarm tab on the HMI device. This will show a list of the alarms that are present or have been present since the system has started up. Refer to Section 7.3 – cDAQ Alarms for more details.

7 cDAQ TOUCHSCREEN OPERATION

The cDAQ touchscreen Human-Machine Interface (HMI) is mounted on the Operator Panel covered by a lockable panel (see Figure 61 below). The cDAQ touchscreen is connected to the cDAQ controller mini-display port with USB touch interface. A USB wireless keyboard/mouse pad combo is installed as an addition user interface to the cDAQ. The wireless keyboard/mouse pad combo is stored in the tool chest.

The cDAQ touchscreen HMI runs on Windows 7 with an embedded National Instruments® LabVIEW Developed application. The cDAQ touchscreen HMI is used to configure the HyStEP for fueling tests, to display/handle alarms, to troubleshoot, to adjust inputs/outputs, and to display/download data captured from tests.

This section provides detailed instructions on how to login, how to navigate, and how to operate the HyStEP device via the cDAQ touchscreen HMI.



FIGURE 61 – cDAQ OPERATOR CONTROL PANEL

7.1 HMI MAIN DISPLAY

Unlock and open the panel as shown in Figure 61 to access the touchscreen HMI. When the trailer is connected to 120V power, the cDAQ and HMI touchscreen will boot up automatically.

7.1.1 Start-up & Login

After the trailer is powered up, Windows login screen will display on the screen. Operators can use the on-screen keyboard or the keyboard/mouse combo to enter user name and

password to log on to Windows. Once logged on, the operator can double click on the icon “H2_Test_4.2” on the desktop to launch the cDAQ application manually as shown in Figure 63.



FIGURE 62 – cDAQ TOUCHSCREEN HMI

Obtain your Windows user name and password from the system administrator.



Note: If the electrical power is provided to the trailer and the HMI touchscreen remains blank, cDAQ may be in sleep mode (screen saver) and touching the screen and/or hitting keys on the keyboard/mouse combo will wake up cDAQ. If blank screen remains, refer to troubleshooting section in this manual for further instructions.

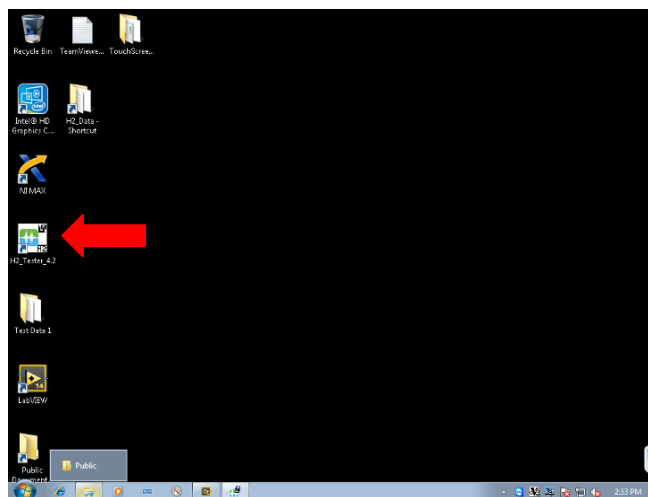


FIGURE 63 – cDAQ APPLICATION SHORTCUT ON WINDOWS DESKTOP

7.1.2 Navigating in HMI

This section is to provide general information for navigating the key functions in cDAQ and operator should refer to Section 8 for specific instructions on fueling tests, defueling, and

purging. The cDAQ touchscreen HMI is designed for touch control by fingers or stylus. Selection and activation can be performed by pressing onto the screen with your finger or stylus. For alpha-numeric input, on-screen keyboard can be brought up by pressing the “Keyboard” as shown in Figure 64. Alternatively, the operator can use the Keyboard/mouse combo provided to navigate in cDAQ just like any standard Windows 7 applications.

When the cDAQ application is launched, a pop-up window is shown for entering information of the trailer operator as well as that of the hydrogen station/dispenser to be tested.



Note: The operator is required to provide the information and click “Validate” before navigating in the cDAQ HMI. The operator can bring up this pop-up window again to make changes to the entered information. The information provided will be stored and used to identify tests and in naming the data files in the system.



Note: Clicking the “Recall” button in the pop-up screen to bring up the information entered previously.

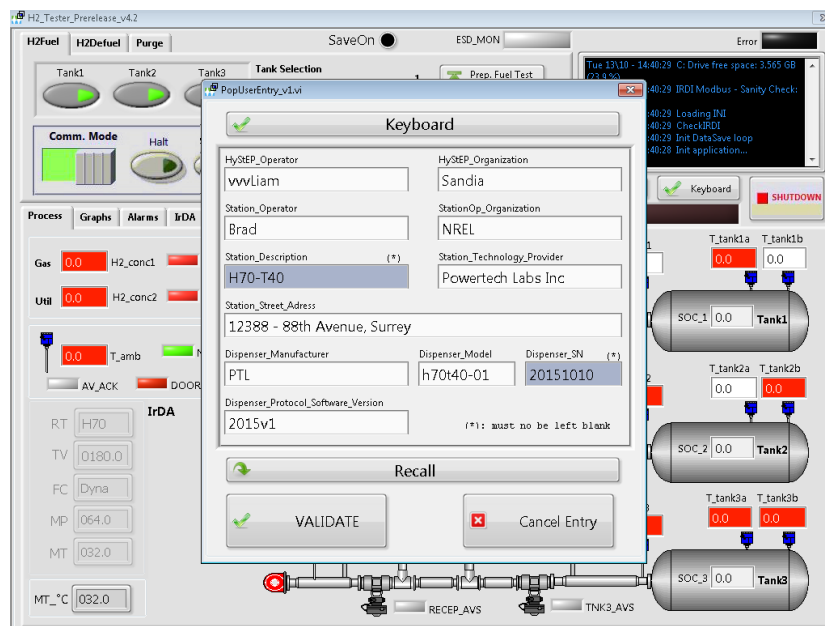


FIGURE 64 – cDAQ HMI STARTUP SCREEN & POP-UP WINDOW

After the pop-up window is closed, the operator will see the Fueling Test Screen as shown in Figure 65.

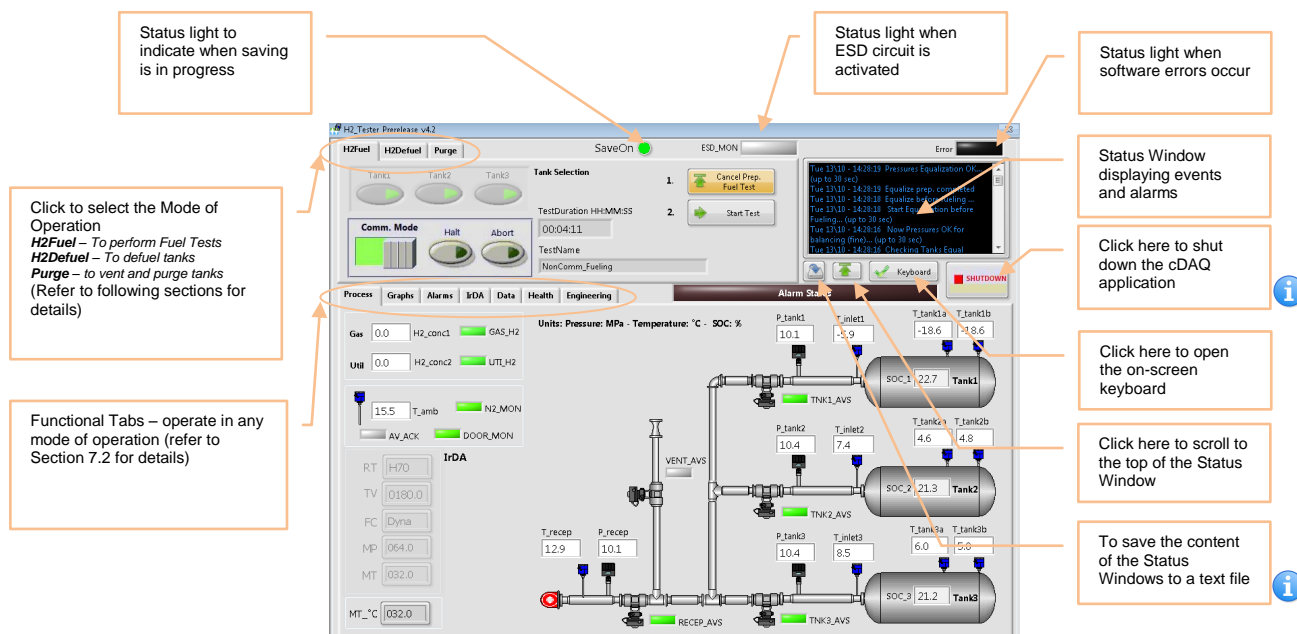


FIGURE 65 – cDAQ DEFAULT SCREEN AFTER LOGGING ON



Note: Shutting down the cDAQ application will stop the data logging and close all valves. After the cDAQ application is shut down, Windows desktop will appear on the touchscreen panel. Restarting cDAQ is possible by clicking the cDAQ application icon on the desktop. If Windows is also shutdown, disconnect & reconnect the electrical plug to the 120VAC source to restart cDAQ.



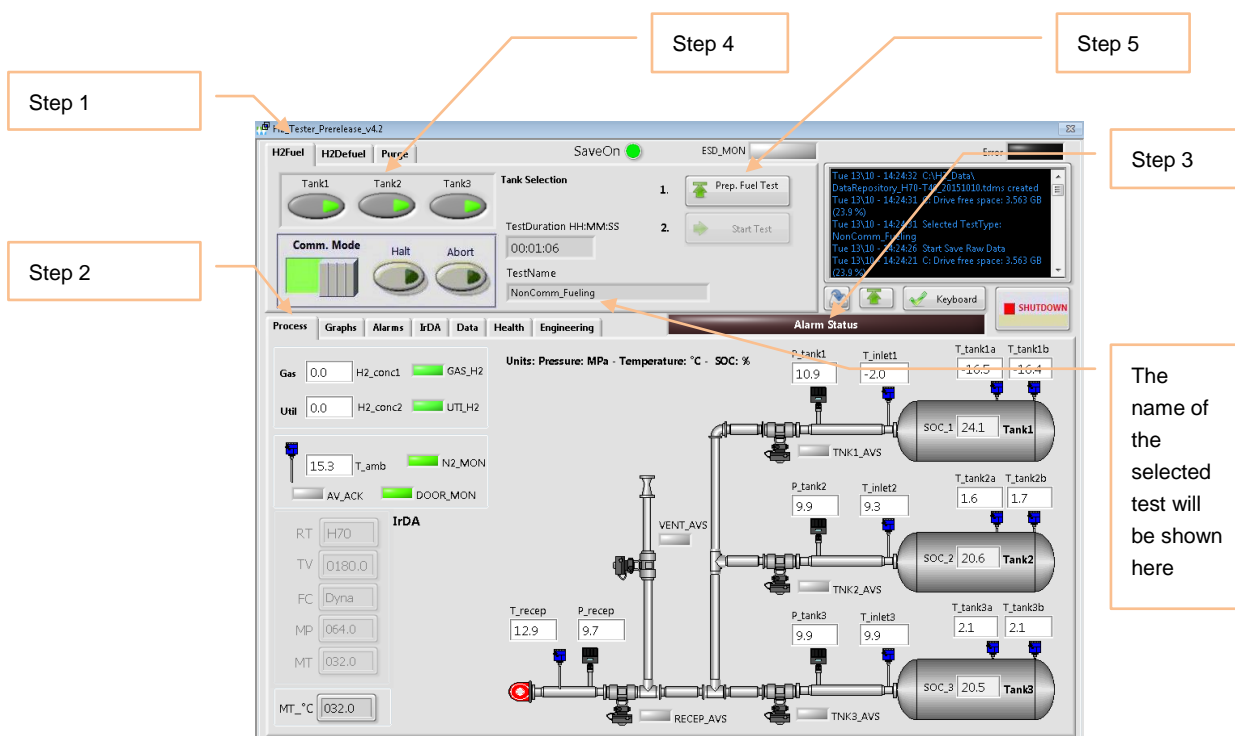
Note: The Status Windows captures the system events & activities after cDAQ is started. It is a valuable tool for troubleshooting and identifying fueling test activities when reviewing data. Operators should save the content of the Status Windows as often as possible.

7.1.3 Fueling Tests

To configure the system for fueling tests, follow the 7 steps in this section. To conduct fueling tests, refer to Section 8 for more detailed procedures.

Step 1 – select “H2Fuel” in the mode of operation.

Step 2 – select the functional tab “Process” to view tank conditions

**FIGURE 66 – cDAQ FUELING TEST PREPARATION SCREEN**

Step 3 – check “Alarm Status” to identify any system alarms (refer to Section 7.3 for alarm handling).

Step 4 – select tanks for the fuel test.



Note: If the differential pressure among the selected tanks is greater than 2MPa, the system will not allow the test to proceed and notify the operator to defuel the tanks first (see 7.1.4 for Defueling Instructions).

Step 5 - press “Prep. Fuel Test” and the following screen will show for the operator to select the desired test type.

Step 6

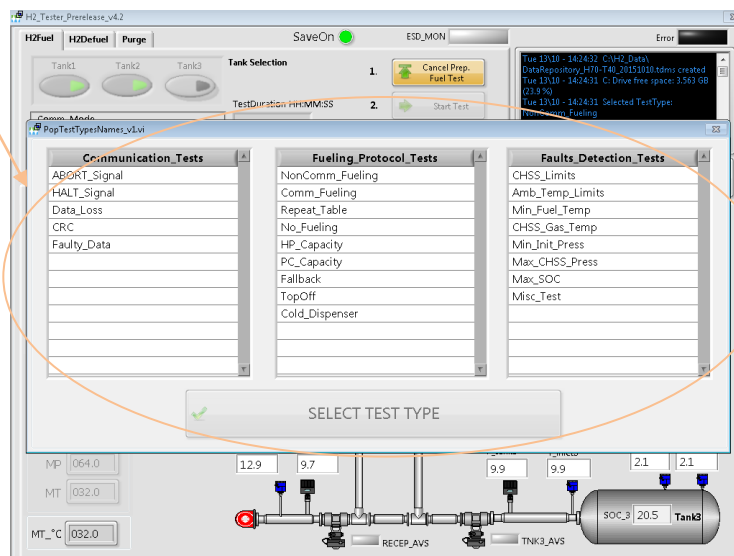


FIGURE 67 – cDAQ PRE-PROGRAMMED TEST TYPE

Step 6 – select the type of test among the 3 columns as shown in Figure 67 and press “SELECT TEST TYPE” to confirm your selection.



Note: There are 3 categories and each category contains different tests. Refer to other sections for details of each test.

Step 7 – Press “Start Test” to initiate the test or press “Cancel Prep. Fuel Test” to go back to prepare the test again (as shown in Figure 68). Refer to Section for detailed fuel test procedures.

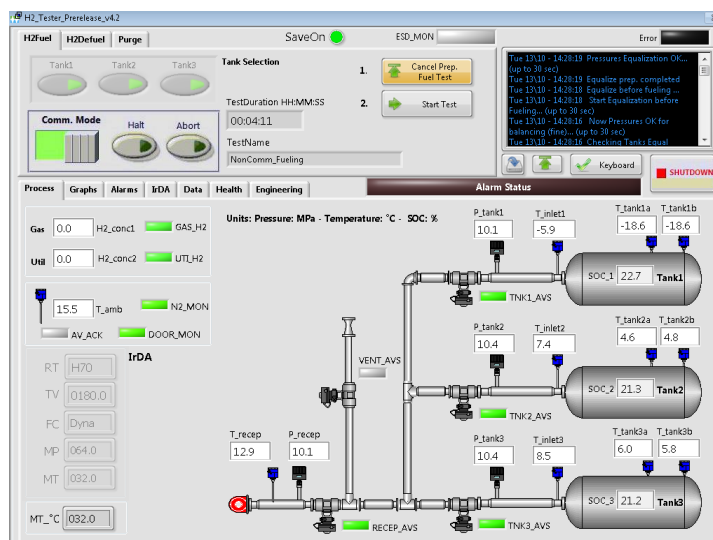


FIGURE 68 – cDAQ FUELING SCREEN (READY FOR TEST)

7.1.4 Defueling

Click “Defuel” to switch the mode of operation to defueling as shown in Figure 69. Go to Section “Defueling Procedure” for detailed instructions on how to defuel the tank(s).



Caution: Failed to follow the defueling instructions may cause equipment failure and/or injury.

Click here to go to the defueling screen

Select tank to defuel

Tank defuel target pressure

Defuel Stop/Start. Clicking “Start Defuel” will open the pneumatic valves of the receptacle, vent, and the selected tanks. Clicking the “Stop Defuel” will close all pneumatic valves.

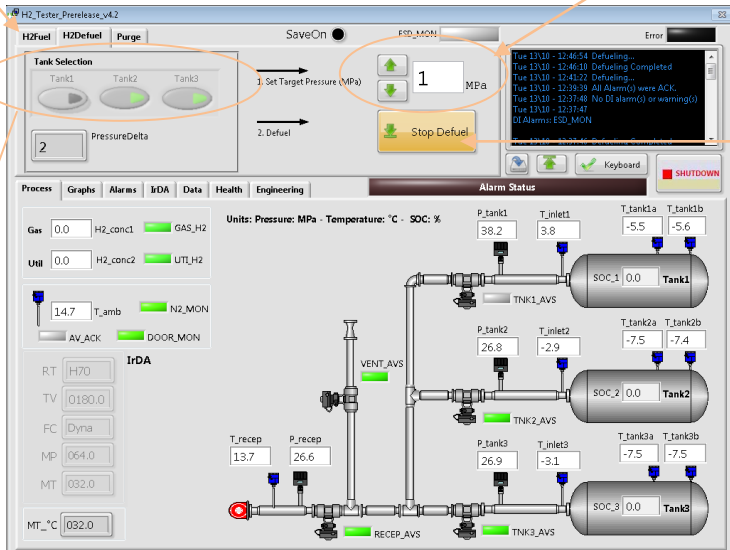


FIGURE 69 – cDAQ DEFUEL SCREEN

7.1.5 Purging

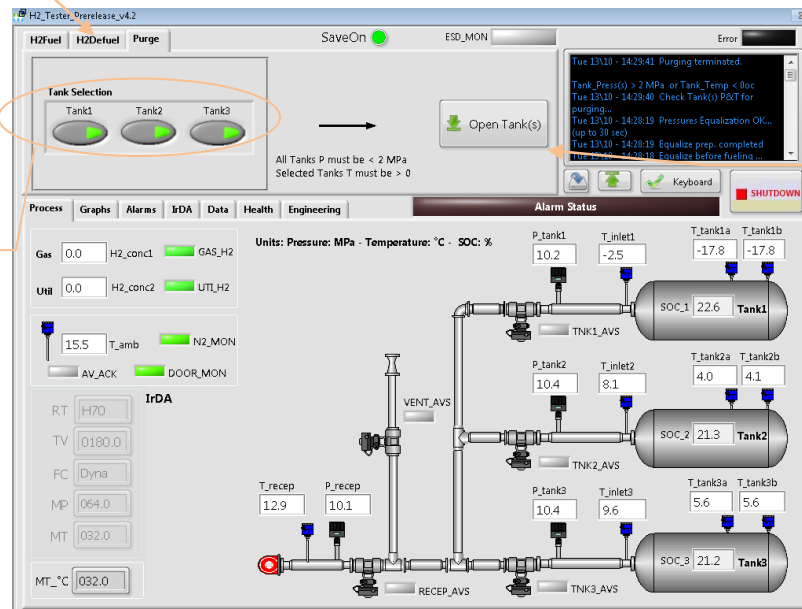
Click “Purge” to switch the mode of operation to purging as shown in Figure 70. Go to Section “Purging Procedure” for detailed instructions on how to purge the tank(s).



Caution: Failed to follow the purging instructions may cause equipment failure and/or injury.

Click here to go to the Purge screen

Select tank to purge



Click to open selected tank(s). Clicking "Open Tank(s)" will open the pneumatic valves of the receptacle, vent, and the selected tanks.

FIGURE 70 – cDAQ PURGE SCREEN

7.2 HMI FUNCTIONAL TABS

7 functional tabs are available at each mode of operation. They can be selected at any time by clicking the desired tabs as shown in Figure 71.

7.2.1 Process

This functional tab is to illustrate the key components of the system in a schematic diagram and the display the following real-time parameters measured/controlled by cDAQ.

- T_recep* – gas temperature near the receptacle
- P_recep* – gas pressure near the receptacle
- P_tank#* - gas pressure near the inlet of tank#
- T_inlet#* - gas temperature near the inlet of tank#
- P_inlet#* - gas pressure near the inlet of tank#
- T_tank#a* - gas temperature inside tank# (near the end of the tank)
- T_tank#b* - gas temperature inside tank# (close to the middle of the tank)
- RECEP_AVS* – position of the receptacle pneumatic valve (green when open)
- VENT_AVS* - position of the venting pneumatic valve (green when open)
- TNK#_AVS* - position of the inlet pneumatic valve of tank# (green when open)
- H2_conc1* - hydrogen level (%LEL) in Gas Room
- GAS_H2* – gas alarm from the gas detector in Gas Room (green when normal)
- H2_conc2* - hydrogen level (%LEL) in Utility Room
- UTL_H2* – gas alarm from the gas detector in Utility Room (green when normal)
- T_amb* – ambient temperature
- N2_MON* – the status of nitrogen supply pressure (green when normal)
- DOOR_MON* – the status of the trailer back door (green when open)
- AV_ACK* – the status of the momentary alarm acknowledge button on the operator panel
- ESD_MON* – the status of the Emergency Shut Down (ESD) circuit
- SOC_#* - % state of charge of tank #

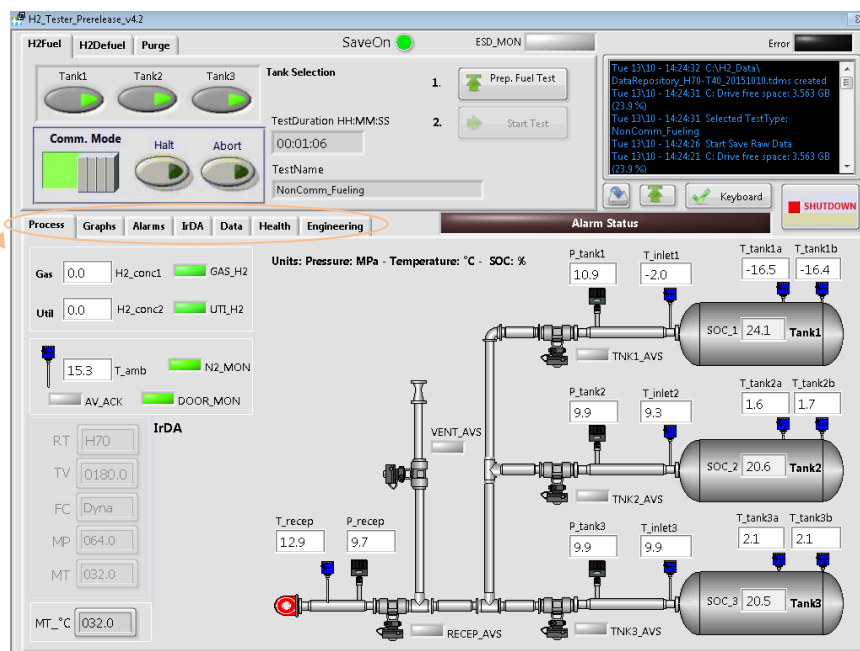


FIGURE 71 – cDAQ FUNCTIONAL TAB “PROCESS”

7.2.2 Graphs

This Graphs tab is to show the real-time parameters measured/controlled by cDAQ in 2 graphs (analog inputs and temperatures) as shown in Figure 72.

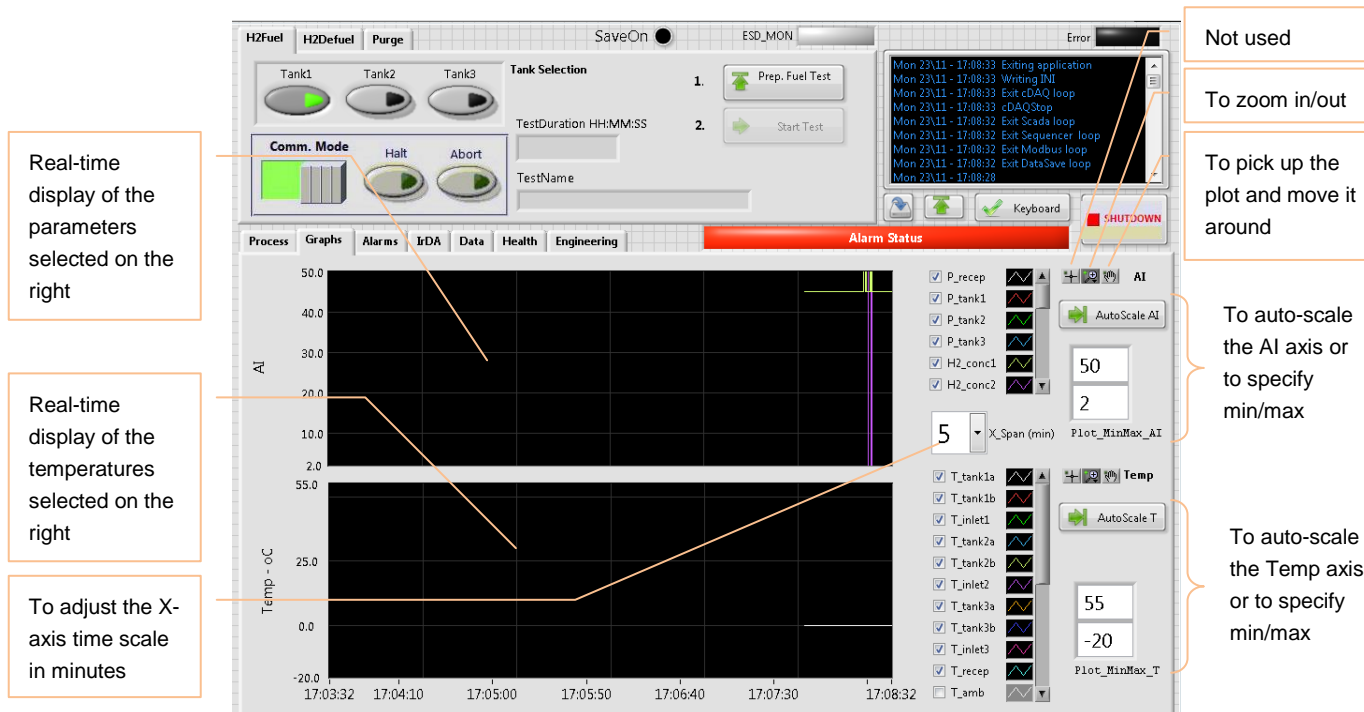


FIGURE 72 – cDAQ FUNCTIONAL TAB “GRAPHS”

7.2.3 Alarms

The left side of this functional tab is to display system alarms and allow the operator to acknowledge the alarms. The right side of the tab is to display the warning, alarm, wiring fault, and hysteresis settings of each point in AlarmInfo and to indicate which warning, alarm, and wiring fault are active.

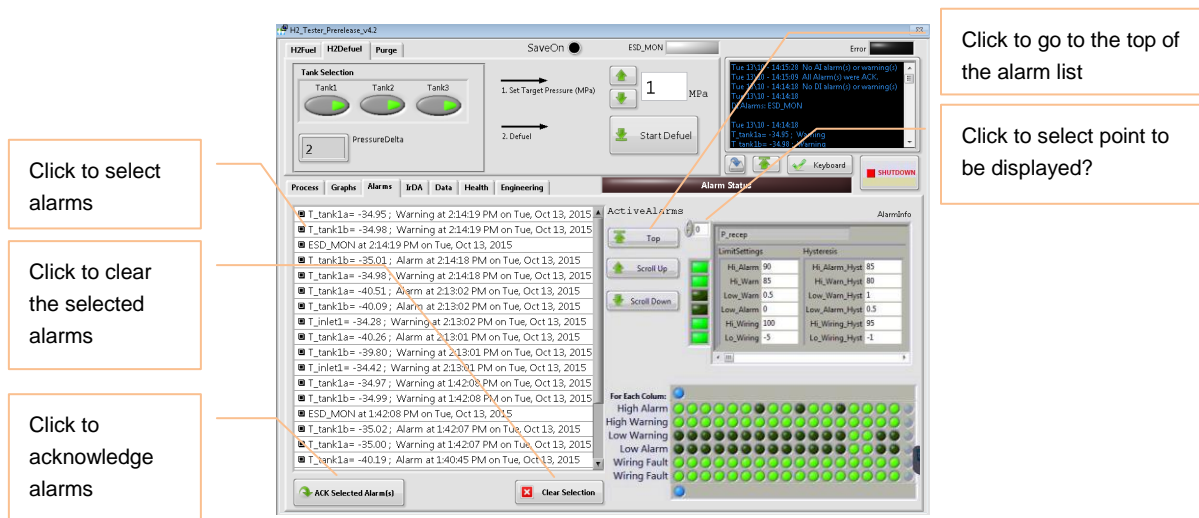
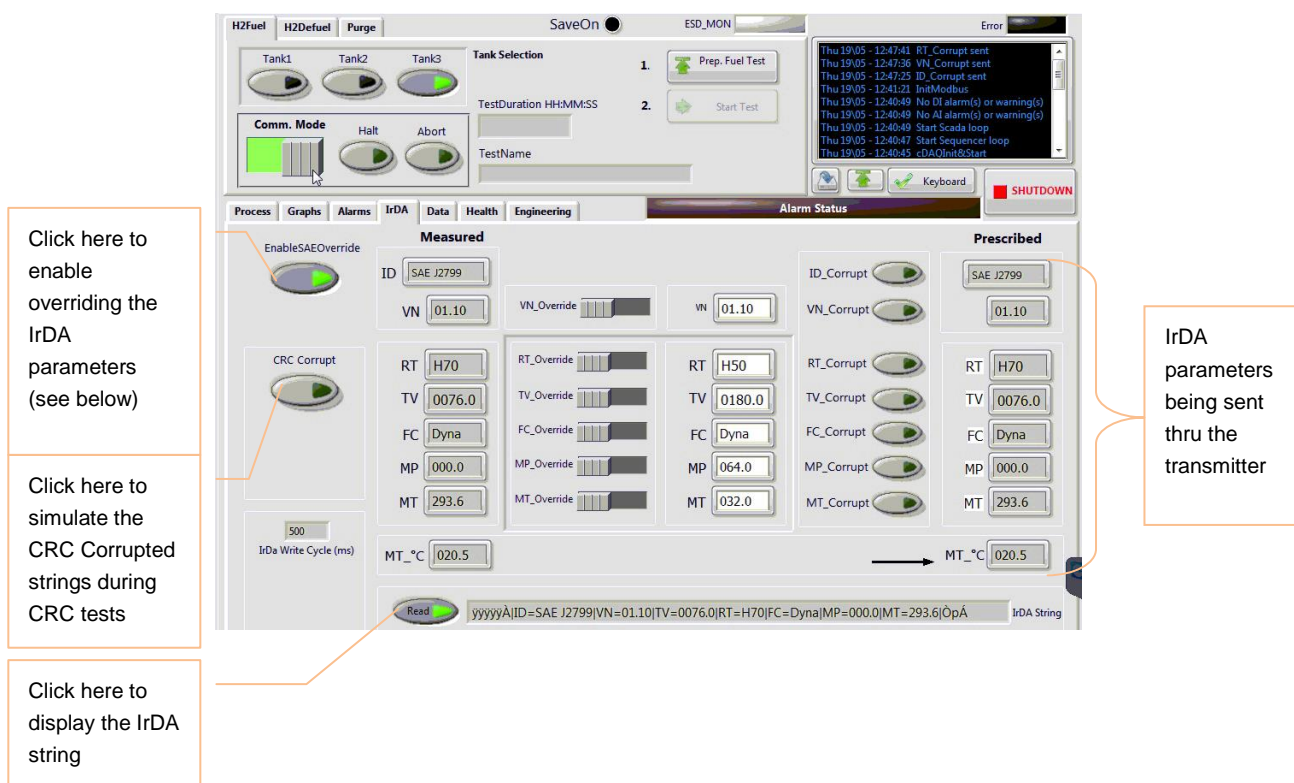


FIGURE 73 – cDAQ FUNCTIONAL TAB “ALARMS”

7.2.4 IrDA

This functional tab is to display the IrDA that are measured by cDAQ and to allow the operator to override each of the IrDA parameters to be transmitted to the dispenser via the IrDA generator & transmitter compliant to the SAE J2799 protocol.



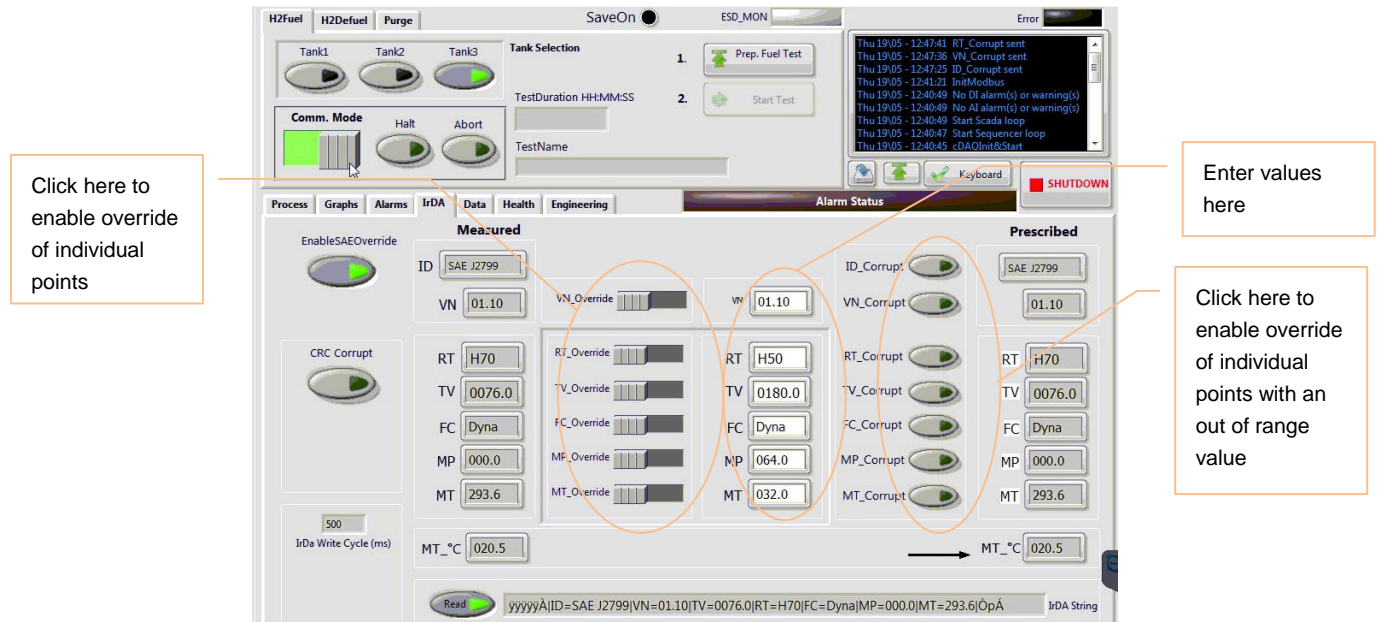


FIGURE 74 – cDAQ FUNCTIONAL TAB “IrDA” (ABOVE) AND WHEN ENABLESAEOVERRIDE IS CLICKED (BELOW)

7.2.5 Data

This functional tab is to display the data file information as well as to allow the operator to make changes to the information entered by the operator when first logged on to cDAQ.



Note: Changes to Station_Description or Dispenser_SN will update the data depository filename.

Click ViewLastDataSet to view the last data set saved in the system.

Click ViewUserDataSet to select user data saved in the system.

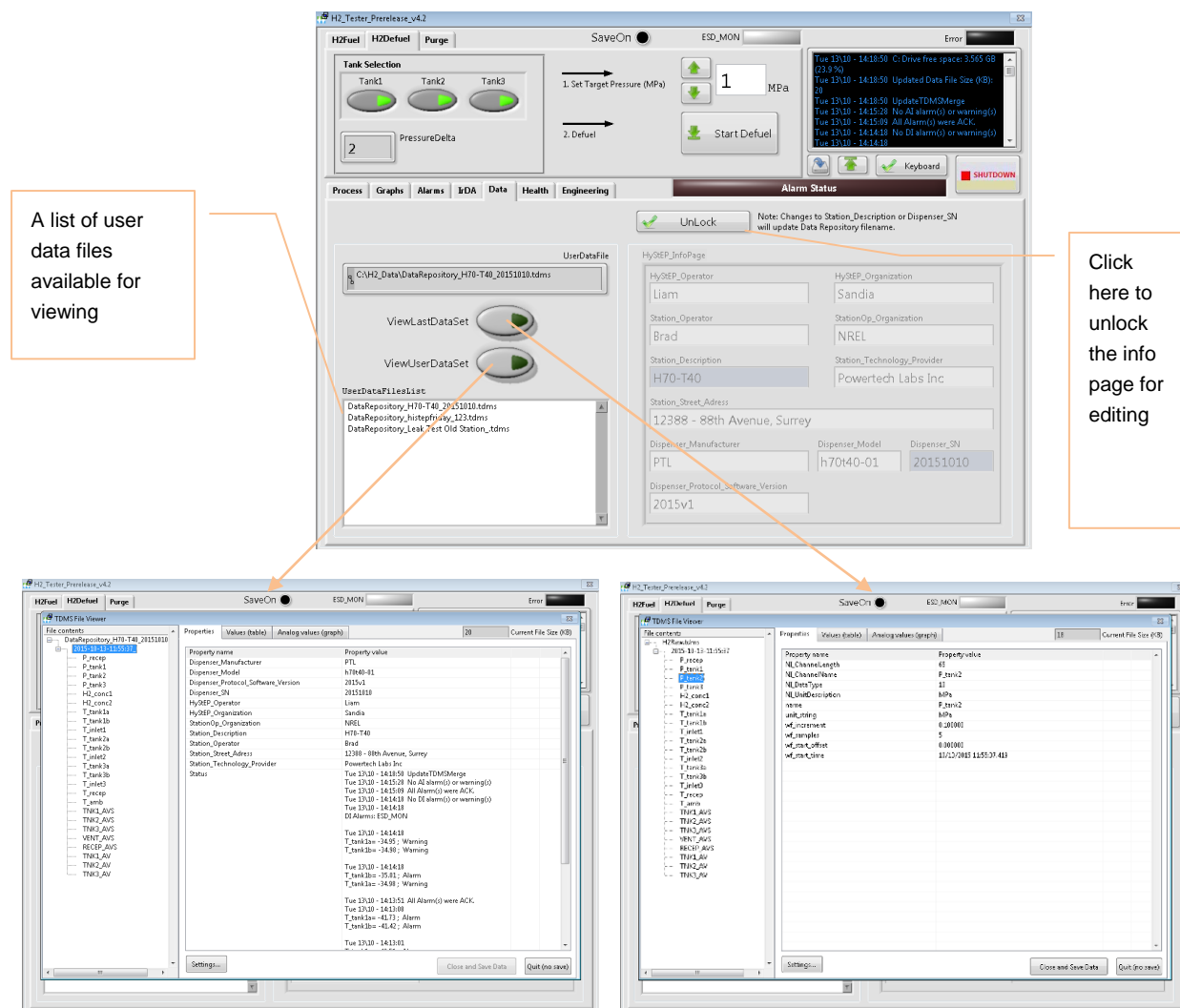


FIGURE 75 – cDAQ FUNCTIONAL TAB “DATA” (ABOVE), VIEWLASTDATASET (BOTTOM RIGHT), AND VIEWUSERDATASET (BOTTOM LEFT)



Note: User data files have the default name “DataRepository_StationDescription_DispenserSN” so that all tests for a given dispenser can be grouped together.

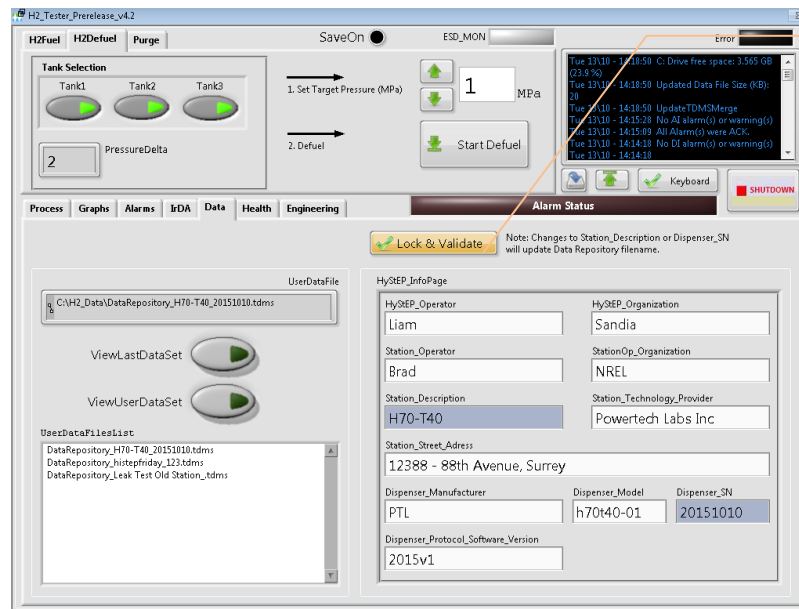


FIGURE 76 – cDAQ FUNCTIONAL TAB “DATA” WHEN INFOPAGE IS UNLOCKED FOR EDITING



Note: If the data depository file is already in the folder, entering the same Station_Description & Dispenser_SN will bring up the existing file and any subsequent test data acquisition will be added to that file.

For Example, in Figure 76, H70-T40 & 20151010 are entered for Station_Description & Dispenser_SN respectively. If there is a file named “DataRepository_H70-T40_20151010” in the data folder, cDAQ will load up the file for any subsequent data acquisition. Otherwise, cDAQ will create a new file named “DataRepository_H70-T40_20151010”.

7.2.6 Health

This functional tab is to give a general view of the overall health of the system by displaying the cDAQ hard drive usage and any errors associated with the GUI, cDAQ, IRDI, and Save. This tab is mainly designed for advanced users and system administrator. However, operator should report to the system administrator if errors occur.

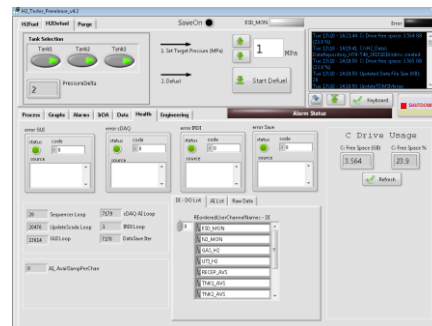


FIGURE 77 – cDAQ FUNCTIONAL TAB “HEALTH”

7.2.7 Engineering

This functional tab is password-protected and reserved for advanced users and system administrator, allowing I/O point overriding, signal adjustment of pressure transducers & thermocouples, setpoint adjustment of defueling target pressure & tank pressure differential limit, new data repository file, selection of Modbus Port, and adjustment of BalanceCheckTime.



Danger: This is an advanced user interface allowing I/O points to be overridden regardless of system conditions. System alarm or built-in safety may not function to warn/protect the user/equipment. All users must have adequate knowledge of the HyStEP device and must review the entire system installation and current conditions prior to using this tab. Unauthorized use is strictly prohibited.

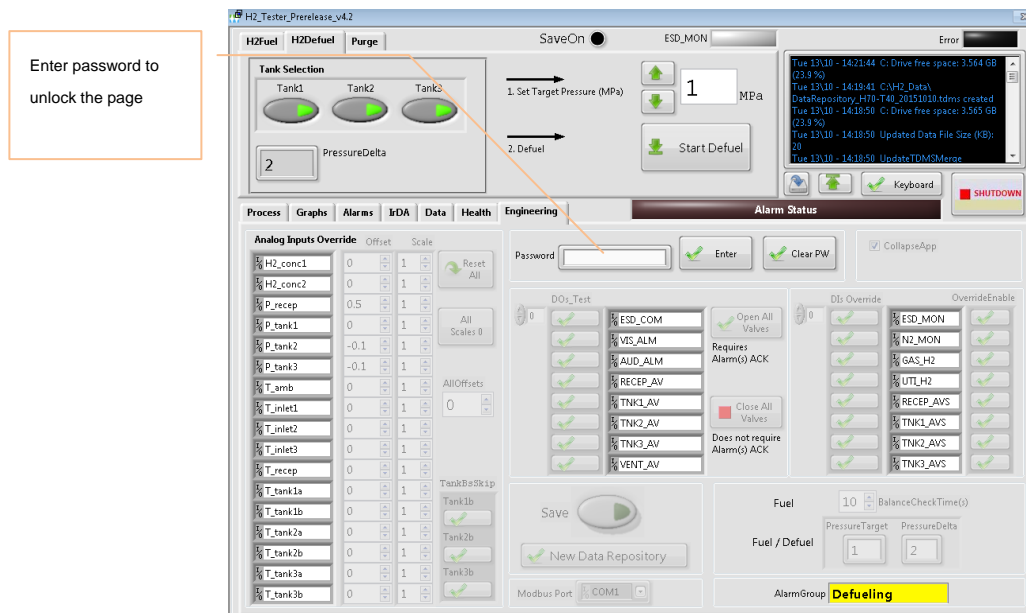


FIGURE 78 – cDAQ FUNCTIONAL TAB “ENGINEERING” WHEN LOCKED

Once the correct password is entered, the system will unlock the screen as shown in Figure 79 and the operator will be able to override the system.



Note: The system is programmed to time-out the “Engineering” tab when unlocked as a security feature. The operator will need to re-enter the password to unlock the “Engineering” tab when time-out.

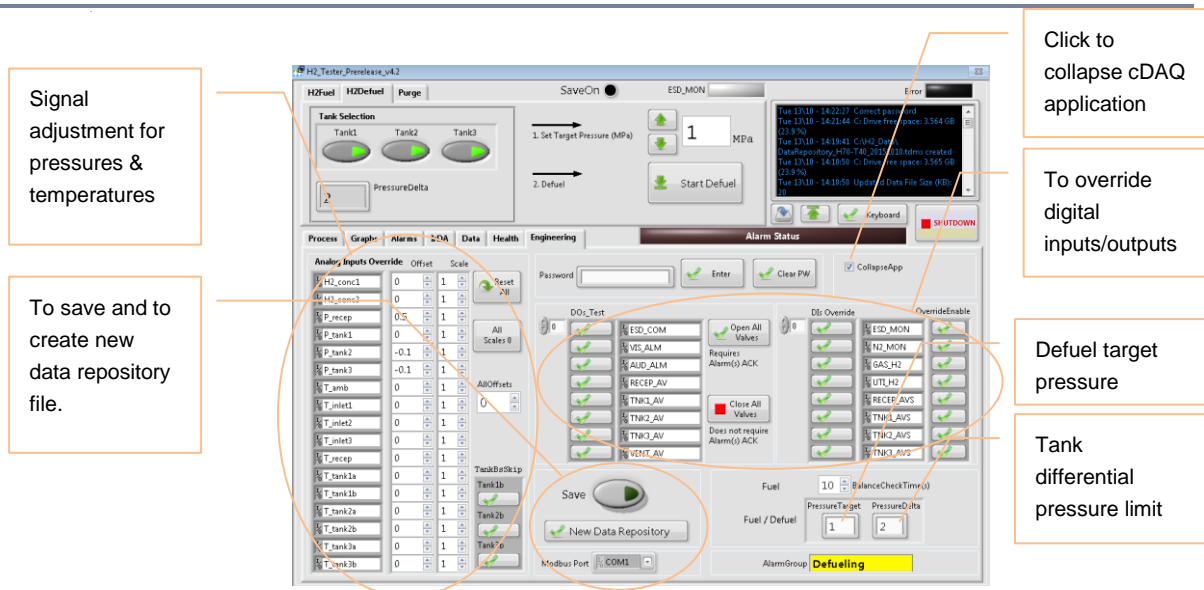


FIGURE 79 – cDAQ FUNCTIONAL TAB “ENGINEERING” WHEN UNLOCKED

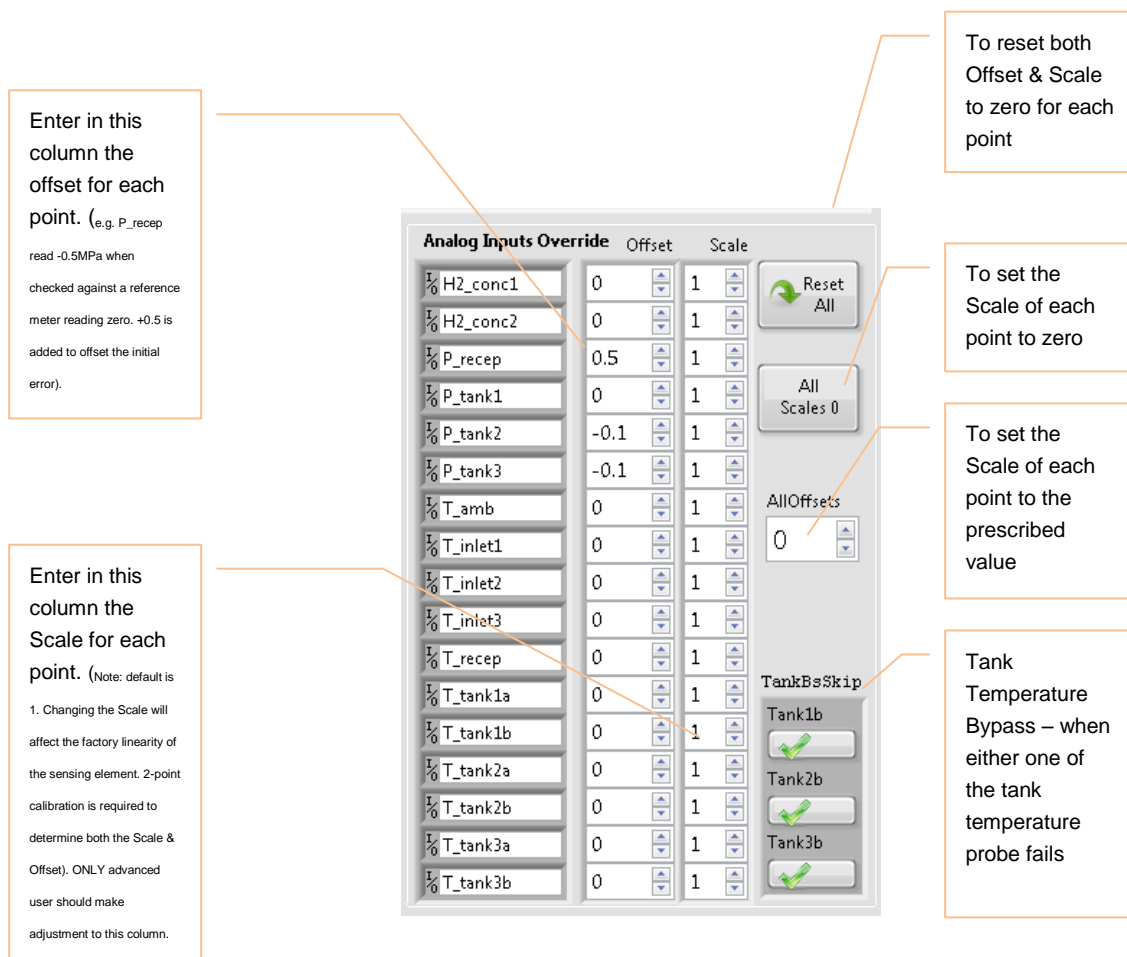


FIGURE 80 – cDAQ PRESSURE TRANSDUCER & THERMOCOUPLE ADJUSTMENT IN “ENGINEERING”

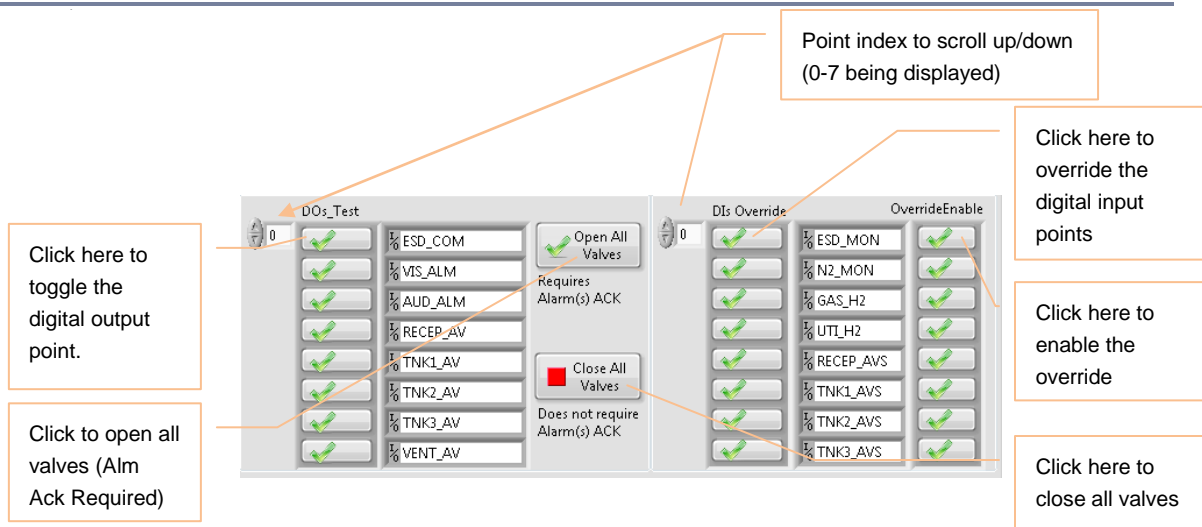


FIGURE 81 – cDAQ DIGITAL INPUT & OUTPUT OVERRIDE IN “ENGINEERING”

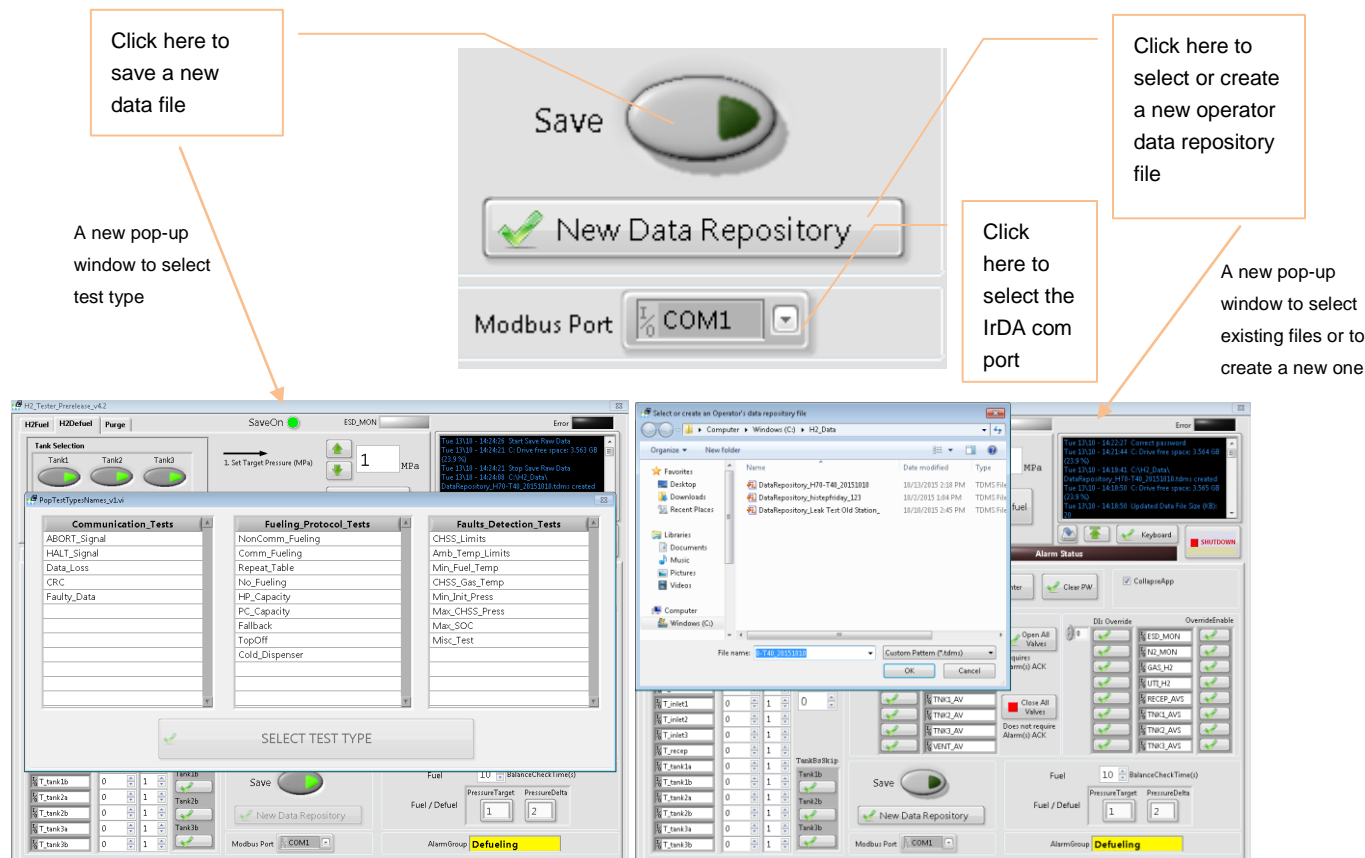


FIGURE 82 – cDAQ DATA REPOSITORY OPERATION IN “ENGINEERING”

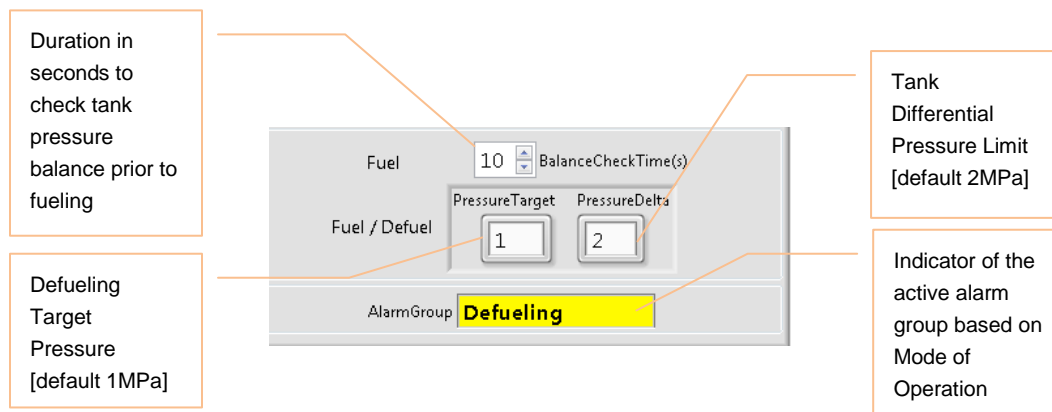


FIGURE 83 – CDAQ FUELING/DEFUELING PARAMETERS IN “ENGINEERING”

7.3 cDAQ ALARMS

7.3.1 Alarm Settings

The alarm settings of each point can be viewed by clicking the “Alarms” tab at any time as shown in Figure 84.

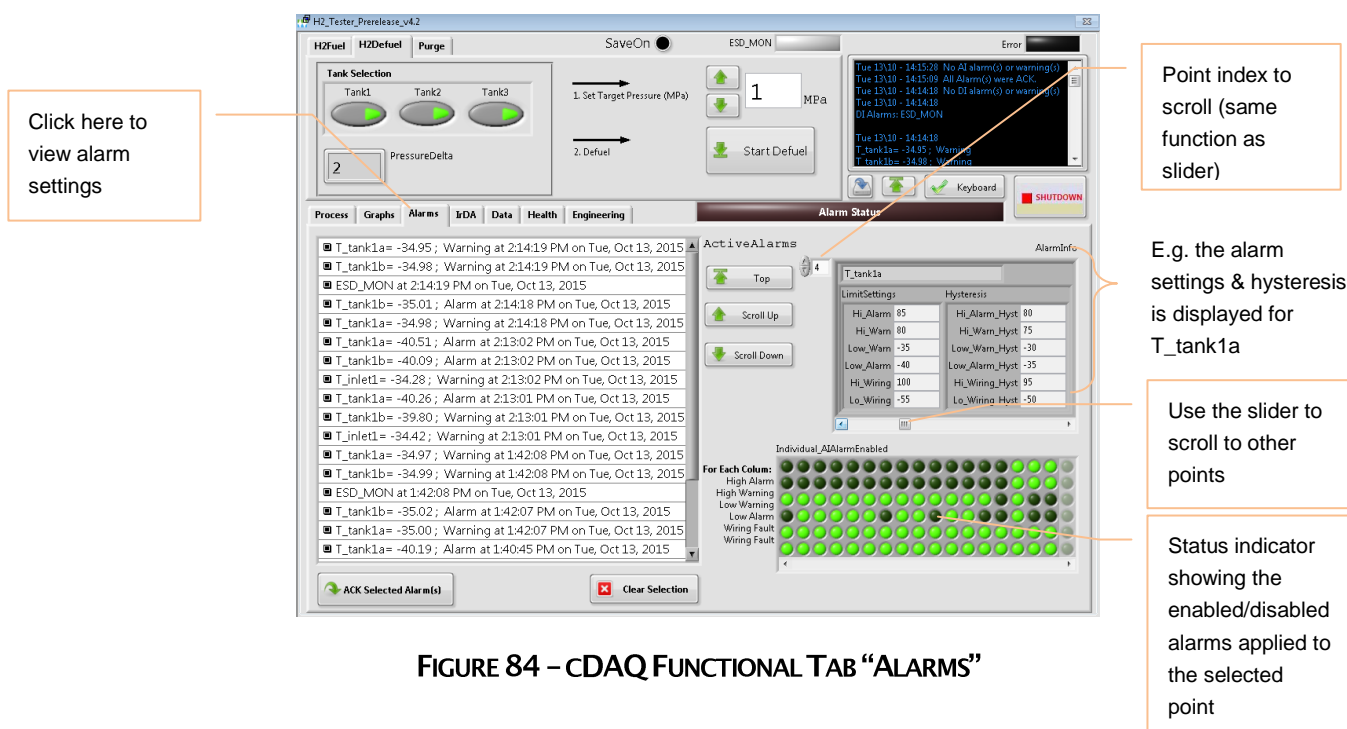


FIGURE 84 – CDAQ FUNCTIONAL TAB “ALARMS”



Note: Refer to Alarm Matrix in Appendix F for alarm configuration details.

7.3.2 Audible Visual Alarm

The HyStEP device is equipped with an audible & visual alarm along with a momentary silence button as a local alarm annunciator panel. They are located above the HMI touchscreen in the Operator Panel. The audible & visual alarm combo is energized by the two cDAQ outputs: one for the audible and one for the visual. When alarm conditions are detected by cDAQ, either the audible, visual, or both (based on alarm types) will be enabled to notify the personnel nearby the trailer.



Note: The visual alarm will stay on during system start-up until cDAQ is fully booted up.

To silence the audible alarm, the operator can push & hold the green button until the audible alarm is off.

The visual alarm will stay on as long as there is one or more active alarm in the system.



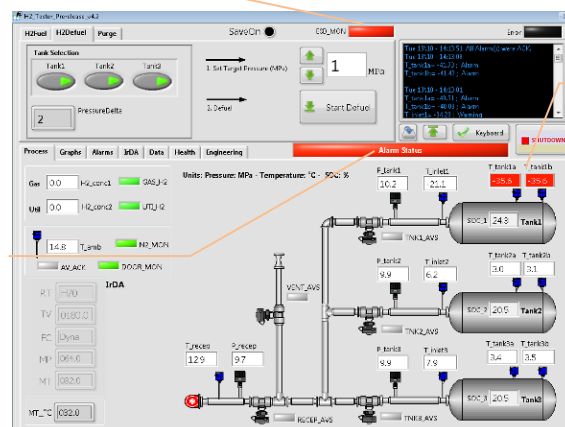
FIGURE 85 – cDAQ AUDIBLE & VISUAL ALARM

7.3.3 Acknowledging an Alarm

When cDAQ detects an alarm as shown in Figure 86, it will display the alarms on the HMI, activate the audible & visual alarm, and/or lock out the system in safe mode according to the Alarm Matrix.

In this particular alarm condition, ESD circuit is activated to lock out the

Alarm Status turns red indicating active alarm in the system



Tank temperatures in alarm and highlighted in red

FIGURE 86 – cDAQ HMI IN ALARM WHILE DEFUELING

To acknowledge an alarm, select the “Alarms” tab to view all system alarms and follow the steps in Figure 87.

The left side of this functional tab is to display system alarms and allow the operator to acknowledge the alarms. The right side of the tab is to display the warning, alarm, wiring fault, and hysteresis settings of each point in AlarmInfo and to indicate which warning, alarm, and wiring fault are active.

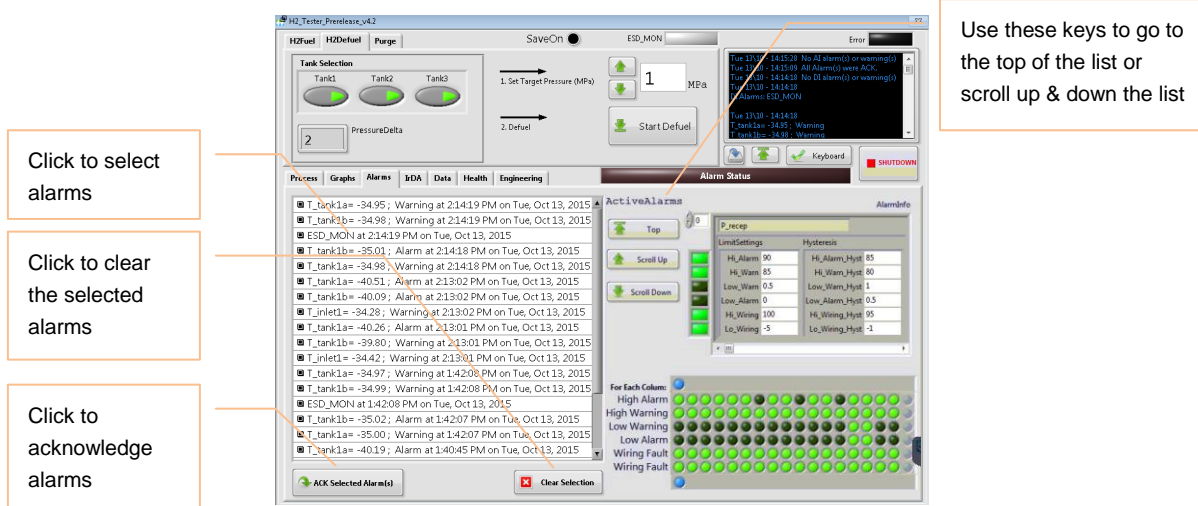


FIGURE 87 – cDAQ FUNCTIONAL TAB “ALARMS” – ACKNOWLEDGING ALARMS

7.4 DATA LOGGING

Refer to Networking & Remote Access of how to connect a computer to the cDAQ local area network. Once a computer is connected to the local area network, follow the steps in this section to download the data files.

Step 1 – Open up Windows Explorer and click Network to view computers in the local area network as Shown in Figure 88. Look for “H2_TESTSTATION” and double-click to connect.

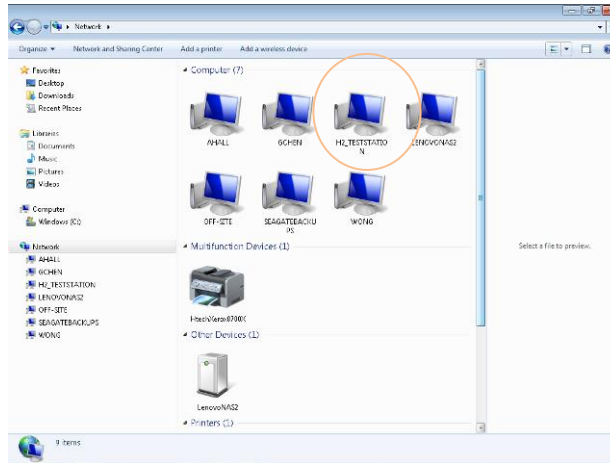


FIGURE 88 – LOCAL AREA NETWORK VIEW IN WINDOWS EXPLORER

Step 2 – Look for folder “H2_data” where all the test data files are stored. Select the folders/files and copy to the computer (see Figure 89).

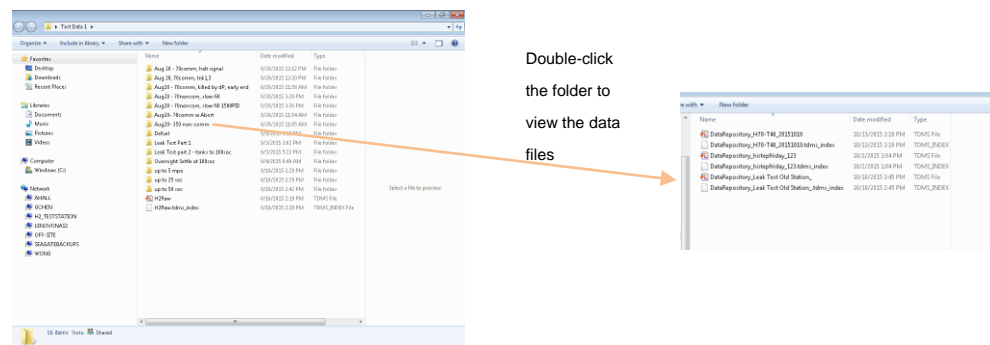


FIGURE 89 – FOLDER VIEW (LEFT) AND DATA FILE VIEW (RIGHT)



Note: The cDAQ data are saved as TDMS files.

8 FUELING TEST SETUP & OPERATING PROCEDURE

8.1 GENERAL

This section illustrates how to set up the system for fueling tests. Operators using this section to conduct any fueling test are expected to be knowledgeable with the rest of this manual.

Prior to executing the fueling test, operator should refer to the current version of CSA HGV 4.3 for test procedures, requirements, and acceptance criteria.



Note: This section assumes that the procedures from Section 6 “Setting Up The HyStEP” have been completed

8.1.1 Tank Preparation & Precautions

Check the tank needle valves to make sure they are all in open position and check the pressure of each tank



Caution: Tank needle valves are isolation valves for service and troubleshooting and shall remain open at all time under normal operation and during transport & storage.

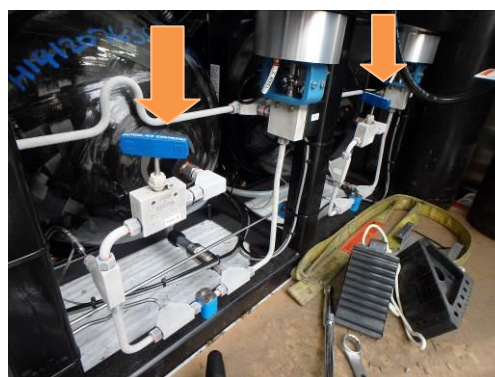
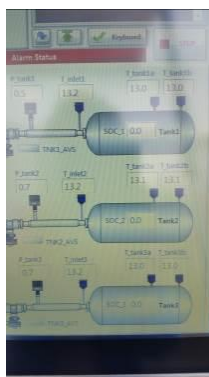


FIGURE 90 – TANK PRESSURE GAUGES ON OPERATOR PANEL (LEFT), TANK PRESSURE DISPLAYED ON HMI (MIDDLE), AND TANK NEEDLE VALVES (RIGHT)

8.1.2 Safety Check

During fueling test, the control system (cDAQ) will constantly monitor the system parameters to alert the operator of any anomalies and to shut down the system if unsafe conditions are detected. However, the operator should monitor the pressure gauges on the Operator Panel and the Nitrogen Purge & Instrument Control Panel to check against abnormal pressure readings and low nitrogen supply to instrument pneumatic controls.



FIGURE 91 – PRESSURE GAUGES ON OPERATOR PANEL (RIGHT), AND NITROGEN PURGE & INSTRUMENT CONTROL PANEL (LEFT)

8.1.3 Test Selection

To configure the cDAQ for fueling tests, follow the steps below.

Step 1 – Select “H2Fuel” in the mode of operation.

Step 2 – Select the functional tab “Process” to view tank conditions

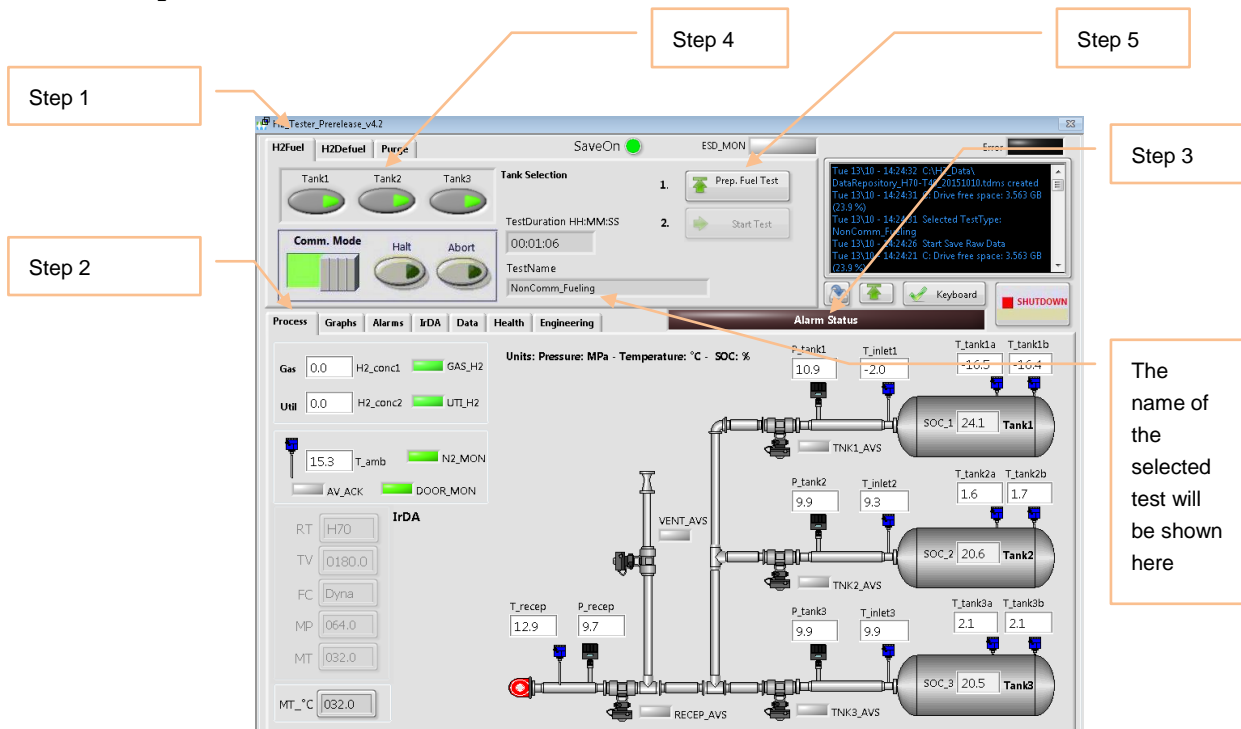


FIGURE 92 – cDAQ FUELING TEST PREPARATION SCREEN

Step 3 – Check “Alarm Status” to identify any system alarms (refer to Section 7.3 for alarm handling).

Step 4 – select tanks for the fuel test.



Note: If the differential pressure among the selected tanks is greater than 2MPa, the system will not allow the test to proceed and notify the operator to defuel the tanks first (see 7.1.4 for Defueling Instructions).



Caution: Do not fill the tanks if the tank temperature is less than -20°C AND tank pressure is less than 2 MPa or damage to the tanks may occur.

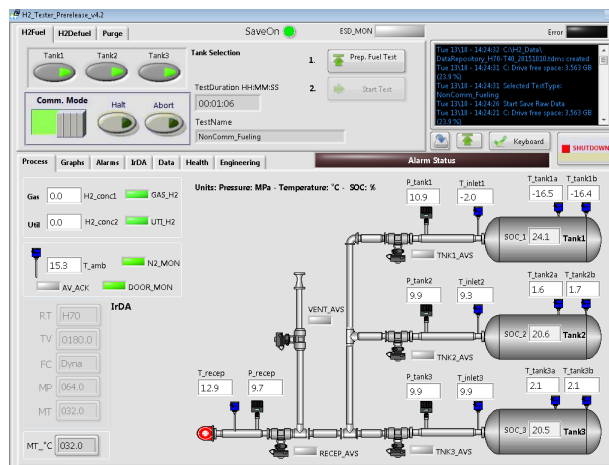


FIGURE 93 – FUELING TESTS – TANK SELECTION

Step 5 - Press “Prep. Fuel Test” and the following screen will show for the operator to select the desired test type.

Step 6

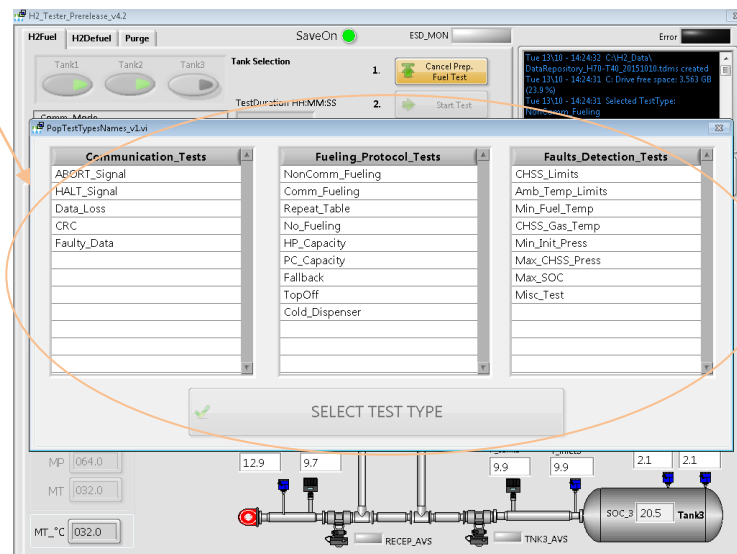


FIGURE 94 – CDAQ PRE-PROGRAMMED TEST TYPE

Step 6 – Select the type of test among the 3 columns as shown in Figure 67 and press “SELECT TEST TYPE” to confirm your selection.

Step 7 - A pop-up will appear asking if the nozzle is connected. Connect the nozzle from the test dispenser to the receptacle of the HyStEP as shown in Figure 95. The nozzle can be left connected to the receptacle in between tests.



Note: The photo illustrates the connection of a WEH® 70MPa Nozzle. For other type of nozzles, such as WalTher® Prazision, please refer to the nozzle manufacturer's specification for connecting procedures.



FIGURE 95 – WEH® NOZZLE CONNECTING TO THE HyStEP RECEPTACLE

Step 7 - Once the pop-up has been acknowledged, the pneumatically actuated valves for the selected tanks will open. A valve that is open will have a green indicator next to it as shown below.

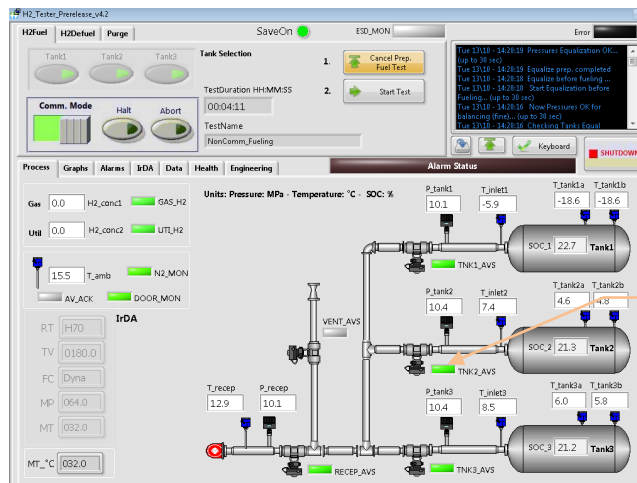


FIGURE 96 – CDAQ FUELING SCREEN (READY FOR TEST)

8.1.4 Starting & Stopping a Test

To start/stop a test, the “Start Test” button shows in Figure 97 will start the test when clicked. Click it again after the test is started will stop the test. When “Start Test” is selected, data will begin logging. When stop test is pressed, the data logging will stop and all pneumatic valves will close.

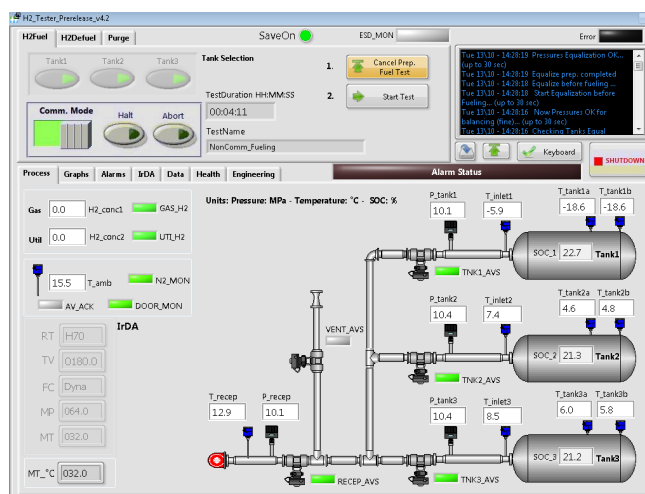


FIGURE 97 – FUELING TESTS – STOP/START A TEST

8.1.5 Review & Download of Test Data

Test data recorded in HyStEP can be reviewed on the HMI touchscreen and/or downloaded to computers for further data processing & analysis.

Review Test Data

To view the data recorded in HyStEP, go to the Functional Tab “Data” as described in Section 7 and select either “ViewLastDataSet” or “ViewUserDataSet”.

When the data repository file is selected, the screen as shown in Figure 98 will display the data file.

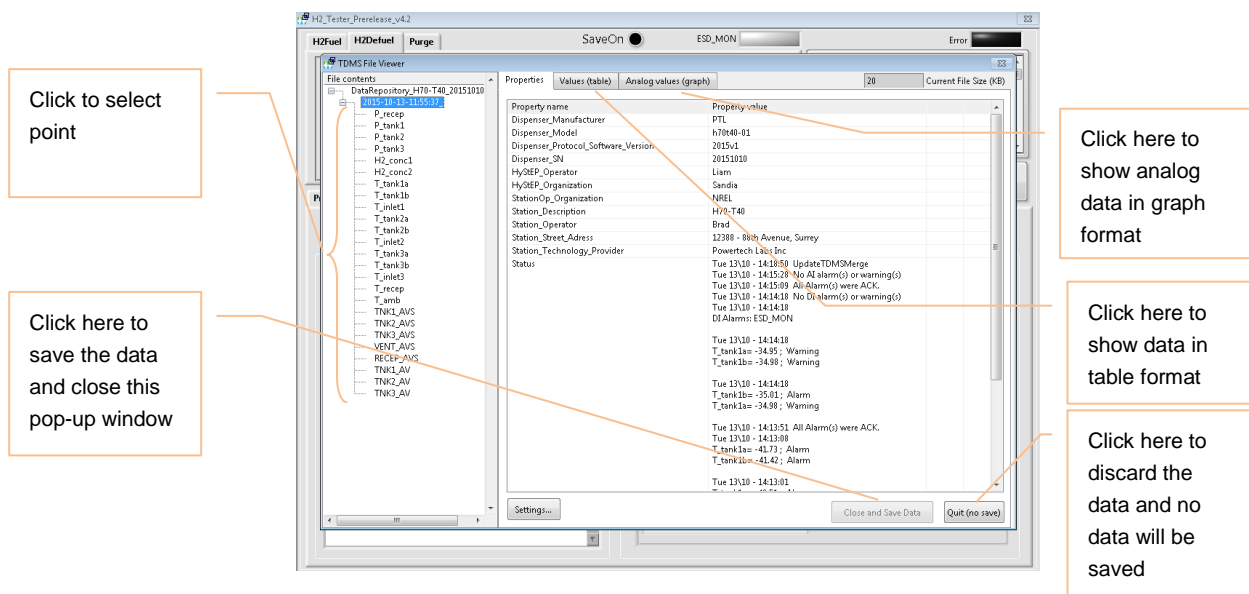


FIGURE 98 – REVIEW RECORDED DATA IN HMI TOUCHSCREEN

Download Test Data

To download the data recorded in HyStEP, connect to the HyStEP local area network as described in Section 5.3. While connecting to the cDAQ controller, look for the folder “H2_Data” as shown in Figure 99. Copy and save the desired data files to the destination folder.

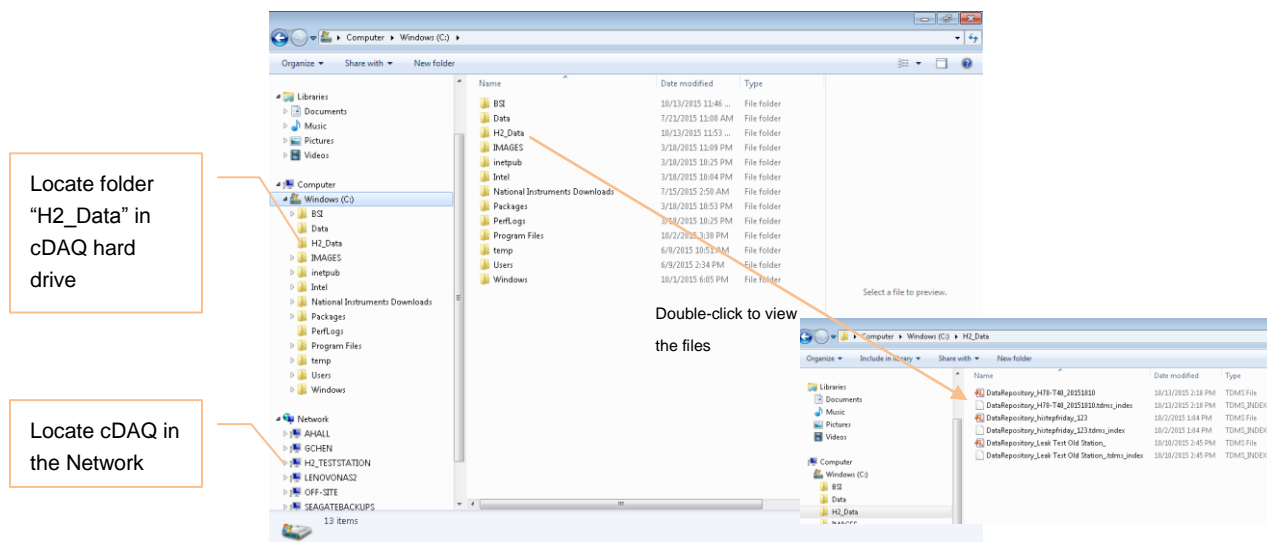


FIGURE 99 – TEST DATA FILE LOCATION IN cDAQ



Note: the cDAQ data files are saved in TDMS format and can be imported to Microsoft Excel with a special add-on application installed to the Excel.

8.1.6 Next Test or Shutdown

To proceed to the next test, refer to Test Selection if the conditions of the tank(s) are suitable to do so. Otherwise, go to Defueling Procedures to bring the tank(s) to the appropriate initial conditions.

If a subsequent test is not needed, click the “Stop” button to close cDAQ application as shown in Figure 100 and then shut down Windows. Refer to Shutdown & Transport Procedures to prepare the HyStEP for transport.

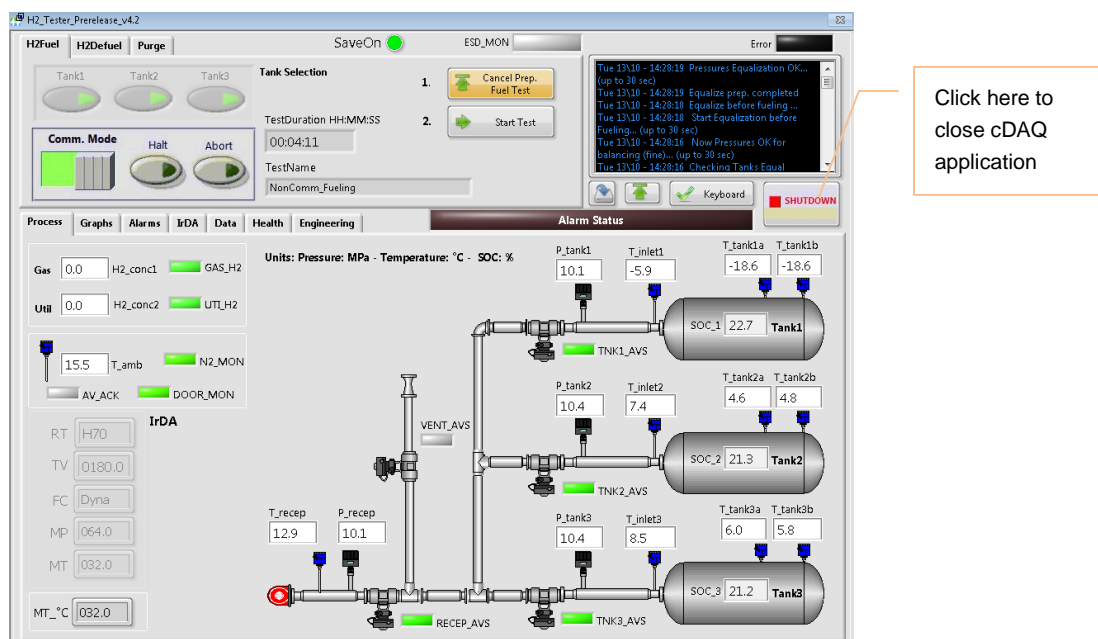


FIGURE 100 – cDAQ SHUT DOWN

8.2 FAULT DETECTION TESTS

Refer to Section 8.1.3 on how to bring up this screen as shown in Figure 101. Select one of the 8 tests in the Fault Detection Tests category for naming the data file. Most of the Fault Detection Tests are simulated with the IrDA override and such an override would not cause the cDAQ to alarm even if the values were beyond the alarm limits.



Note: Some tests in this section require adjusting the dispenser parameters. In that case, HyStEP is only a device displaying real-time readings, monitoring alarms, and recording data. No simulation or override will be performed at HyStEP. The operator shall refer to the latest version of the CSA HGV 4.3 for Hardware Requirements, Pre-test Conditions, Test Procedures, and Acceptance Criteria. For example, Min_Fuel_Temp test would require adjusting the dispenser nozzle temperature signal or the setpoint of the pre-cooler chiller.

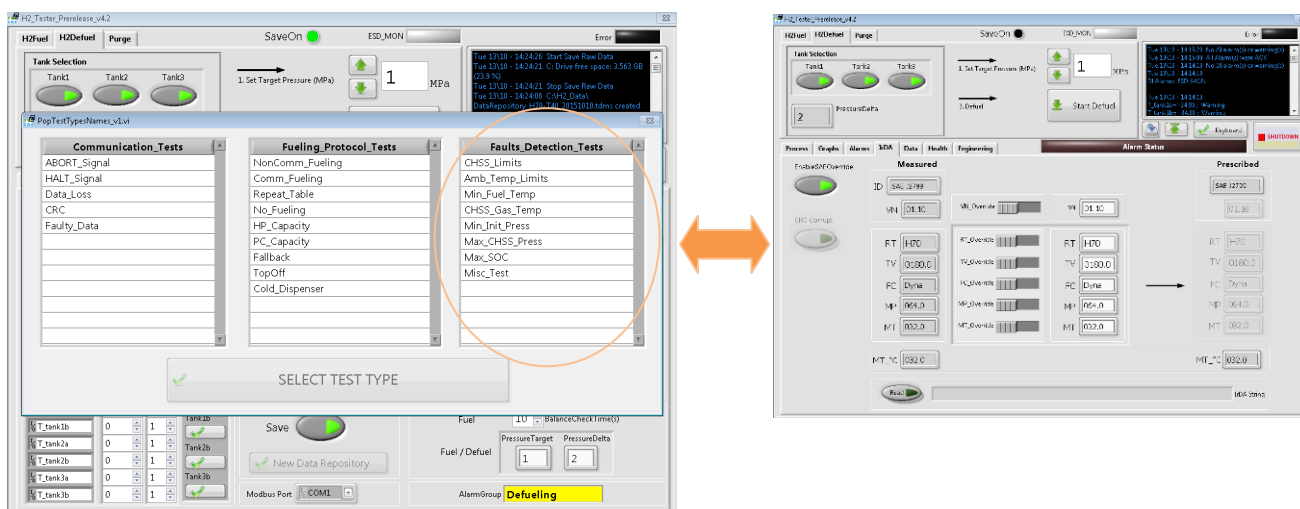


FIGURE 101 – TEST TYPE SELECTION: FAULT DETECTION TESTS (LEFT) & IRDA TAB (RIGHT)



Caution: Do not fill the tanks if the tank temperature is less than -20°C AND tank pressure is less than 2 MPa or damages to the tanks may occur.

8.3 COMMUNICATION TESTS

Refer to Section 8.1.3 on how to bring up this screen as shown in Figure 102. Select one of the 5 tests in the Communication Tests category for naming the data file.



Note: This section is to illustrate the cDAQ touchscreen control for the operator to simulate the test conditions. The operator shall refer to the latest version of the CSA HGV 4.3 for Hardware Requirements, Pre-test Conditions, Test Procedures, and Acceptance Criteria.

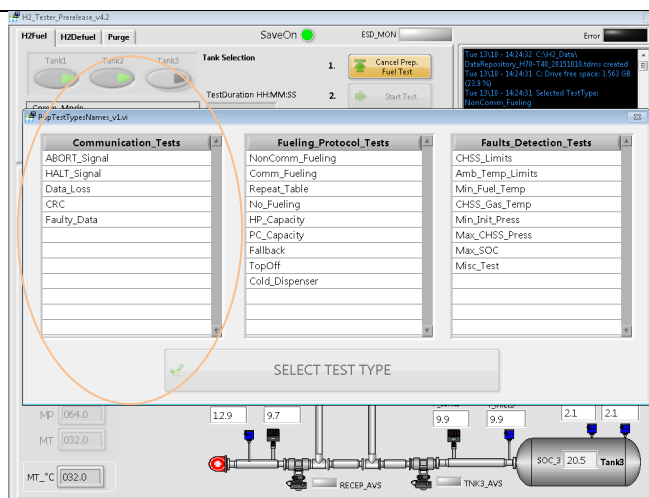


FIGURE 102 – TEST TYPE SELECTION: COMMUNICATION TESTS

During the Communication Test, follow the instructions in Figure 103 to simulate the desired test conditions for Abort, Halt, and Data Loss. For CRC, Faulty Data, and Invalid Defined Data Value tests, refer to Figure 104.

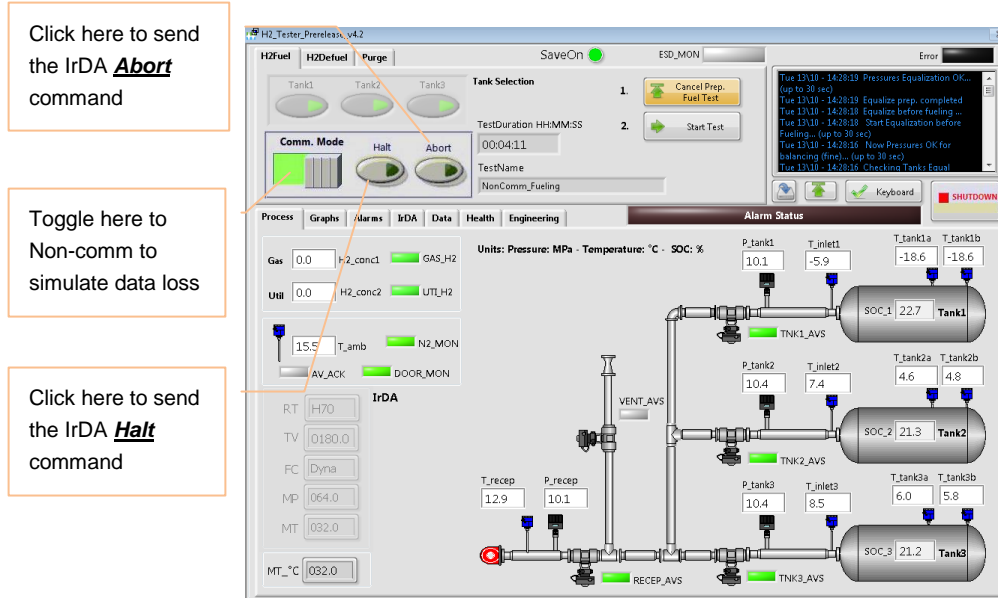


FIGURE 103 – COMMUNICATION TESTS: ABORT, HALT, & DATA LOSS

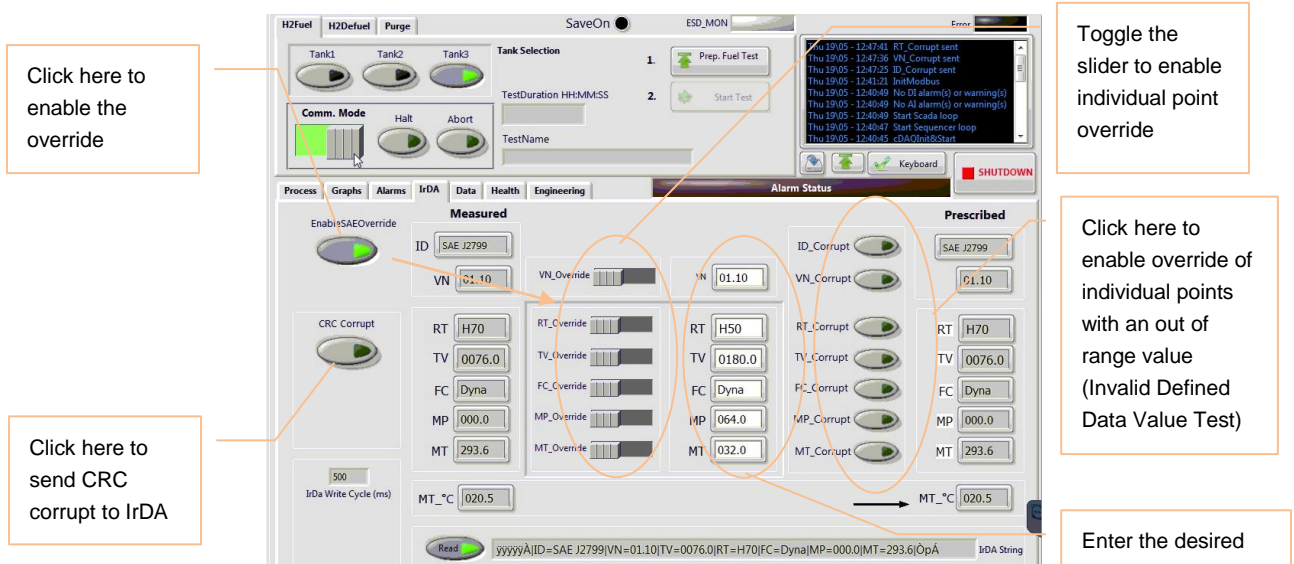


FIGURE 104 – COMMUNICATION TESTS: CRC & FAULTY DATA



Caution: Do not fill the tanks if the tank temperature is less than -20°C AND tank pressure is less than 2 MPa or damage to the tanks may occur.

8.4 FUELING PROTOCOL TESTS

Refer to Section 8.1.3 on how to bring up this screen as shown in Figure 102. Select one of the 9 tests in the Fueling Protocol Tests category for naming the data file.



Note: Most of the Fueling Protocol Tests require the actual tank configurations/conditions to be set according to the requirements in CSA HGV 4.3. The operator shall refer to the latest version of the CSA HGV 4.3 for Hardware Requirements, Pre-test Conditions, Test Procedures, and Acceptance Criteria.

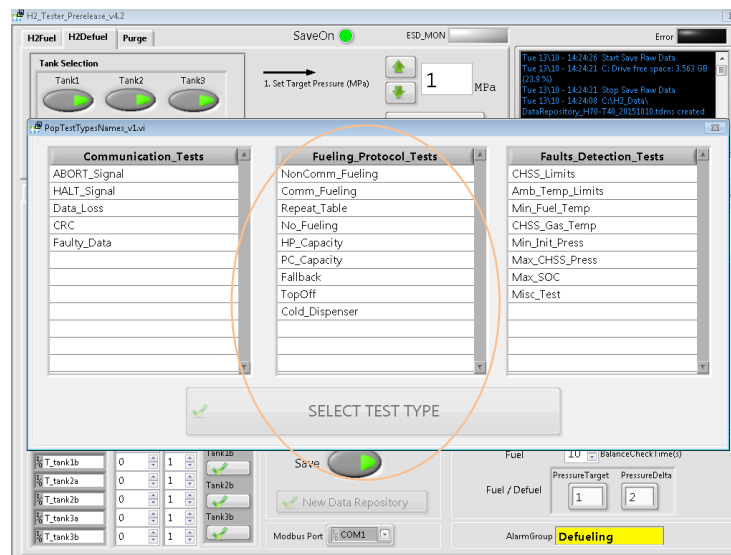


FIGURE 105 – TEST TYPE SELECTION: FUELING PROTOCOL TESTS



Caution: Do not fill the tanks if the tank temperature is less than -20°C AND tank pressure is less than 2 MPa or damages to the tanks may occur.

8.5 SHUTDOWN & TRANSPORT PROCEDURES

8.5.1 Defueling Procedure

To configure the system for defueling, follow the steps in this section.



Caution: The remote vent stack **MUST** be properly installed prior to defueling (refer to “Remote Vent Stack” section for further instructions).



Caution: Venting can be loud and potentially cause hearing damage. Ear plugs should be used when venting.

Step 1 – select “Defuel” in the mode of operation

Step 2 – Set Target Pressure by pressing the up/down arrow to the desired target tank pressure.

Step 3 – Select the tanks for defueling.



Note: If the differential pressure among the selected tanks is greater than 2MP, the system will start defueling the tank(s) with the highest pressure first. When the tank(s) being defueled is within 2MPa of the subsequent tank(s), the system will open the pneumatic valve of the subsequent tank(s) for defueling.



Caution: Make sure the defuel pressure regulator and the defuel valve (located in the operator panel) are fully closed prior to Step 4 – initiating the defueling.

Step 4 – Press the “Start Defuel” to initiate defueling and press again to pause defueling. Initiating defueling will open the receptacle pneumatic valve, the venting pneumatic valve, and the pneumatic valves of the selected tanks providing it is safe to do so.

Step 1

Step 2

Step 3

Step 4

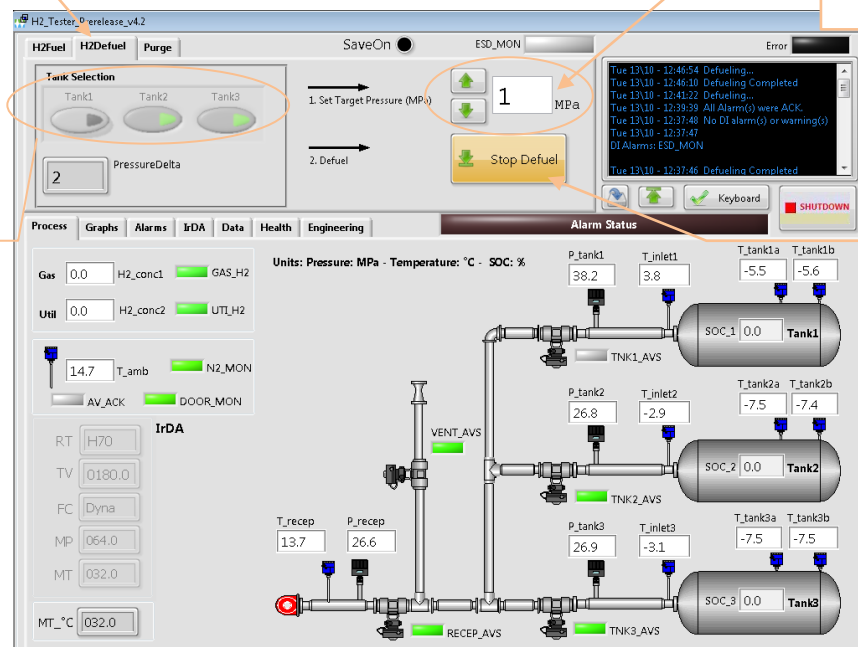


FIGURE 106 – DEFUELING SCREEN WHEN DEFUELING IS ACTIVATED

Step 5 – Turn the defuel pressure regulator clockwise to open until the defuel pressure indicator is between 3MPa and 4MPa.



Caution: If the defuel pressure is below the recommended range and the tank pressure is high, **resonant & vibration** at the defuel pressure regulator may occur when the defuel valve is open (Step 6). If it happens, immediately press the ESD button below the touchscreen to stop defueling.



FIGURE 107 – PRESSURE REGULATOR AND NEEDLE VALVE

Step 6 – Turn the defuel valve slowly counter-clockwise to open and hydrogen will flow thru the remote stack to the atmosphere.



FIGURE 108 – SET REGULATOR ABOVE 3MPa (LEFT), SLOWLY OPEN NEEDLE VALVE (RIGHT)



Note: The system will monitor the system conditions during defueling and stop defueling if any of the tank temperatures are equal to or below -40°C and alarms will be generated.

Step 7 – Once the tank reaches the target pressure, the pneumatic valves of that tank will close and venting will stop when all the selected tanks reach the target pressure.



Caution: If venting is interrupted, close the defuel valve and regulator then follow Steps 4 to 6 again. If the valve and regulator are open when venting commences, it is likely that resonance and vibration in the defuel regulator will occur.

Step 8 – when defueling is done, make sure the defuel pressure regulator and defuel valve are fully closed.

8.5.2 Purging Procedure

To configure the system for purging, follow the steps outlined below:



Caution: The remote vent stack **MUST** be properly installed prior to defueling (refer to “Remote Vent Stack” section for further instructions).



Note: Make sure the nitrogen cylinder is connected to the purge panel.

Step 1 – select “Purge” in the mode of operation

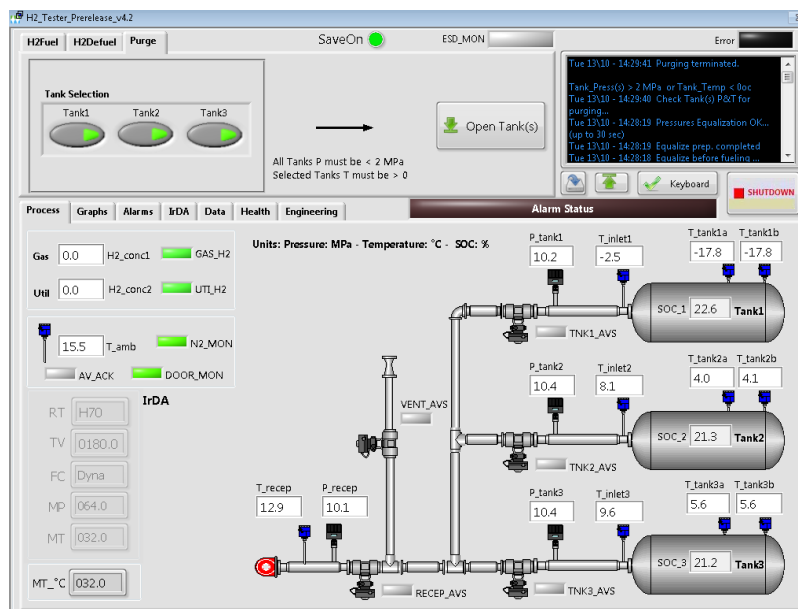


FIGURE 109 – PURGE SCREEN



Caution: make sure the defuel pressure regulator and the defuel valve (located in the operator panel) are fully closed and the Purge Valve & Purge Flow Control valve (on the nitrogen panel) are fully closed prior to Step 2 – initiating purging.

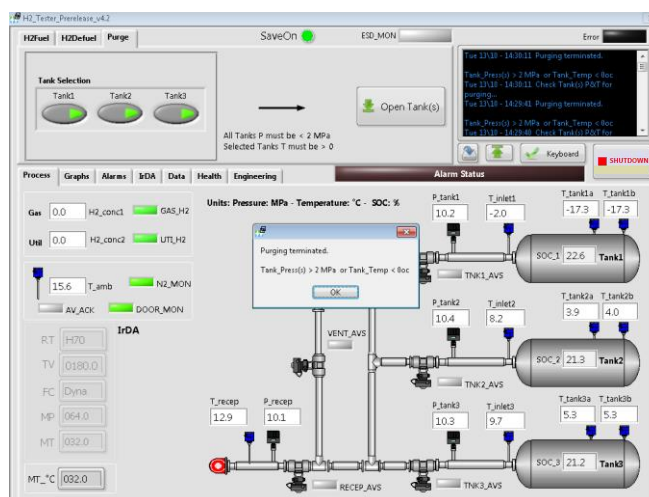
Step 2 – Select the tanks for purging and the system will open the pneumatic valve on the selected tanks providing it is safe to do so.



Note: Selected tank(s) must be below 2MPa and selected tank temperature(s) must be above 0°C before the system will open the valves of the selected tank(s); otherwise, the following screen will pop-up. Click ok to acknowledge the error message and refer to Defueling section to lower the tank pressure below 2MPa. For tank temperature error, wait for the tanks to warm up.



Caution: Do not fill the tanks if the tank temperature is less than -20°C AND tank pressure is less than 2 MPa or damages to the tanks may occur.

FIGURE 110 – ERROR MESSAGE WINDOW DURING PURGING IF $P_{TANK} > 2\text{MPa}$ OR $T_{TANK} < 0^{\circ}\text{C}$

Step 3 – Decide what pressure to vent down to (P_1), the pressure to fill the cylinders with nitrogen must be at least **3.218 times of P_1**

Step 4 – Turn the purge pressure regulator clockwise to open until the purge pressure is around 500 psi as shown in Figure 111.

Step 5 – Turn the Purge Valve handle in parallel to the line to allow nitrogen to flow to the Purge Flow Control Valve which is used to adjust the flow to the tanks. Slowly open the Purge Flow Control Valve



FIGURE 111 – NITROGEN PURGE PANEL

Step 6 – Return to the Purge Screen shown in Figure 109 to monitor the tank pressure.

Step 7 – Close the Purge Flow Control Valve and Purge Valve when the desired tank pressure is reached or the system will stop purging when the tank pressure is equal to 2MPa (refer to Defueling to release the gas inside the tank to the atmosphere).

Step 8 – Go to the Operators Panel and set the Defuel Regulator to approximately 3 MPa

Step 9 – Slowly open the Defuel Valve and vent the tanks down to P1

Step 10 – Repeat steps 5 to 9 two more times for a total of 3 purges, at the end of which the tanks should contain less than or equal to 3% molar hydrogen concentration.

Step 11 –Select “Close Tanks” on HMI



Note: To prepare the tanks for transport (prior to DOT certification), defuel the tank down to 0.2MPa and purge with nitrogen to 2MPa at least 3 times. The tanks shall be at no greater than 0.2MPa after purging for transport.

8.5.3 cDAQ Shutdown Procedure

Before shutting down the cDAQ, take a note of the SOC in the tanks or take a picture of the screen. Upon next use compare the values on the screen with these values to verify that no leaks have occurred.

When ready to power off the device, select the “Shutdown” button as shown in Figure 112. This will close the HyStEP Software. Then move the mouse to the bottom of the screen to bring up the task bar, select the Windows icon and then select “Shut Down”. This will shut down the cDAQ. Once this is complete, the power can be disconnected without adversely affecting the cDAQ.

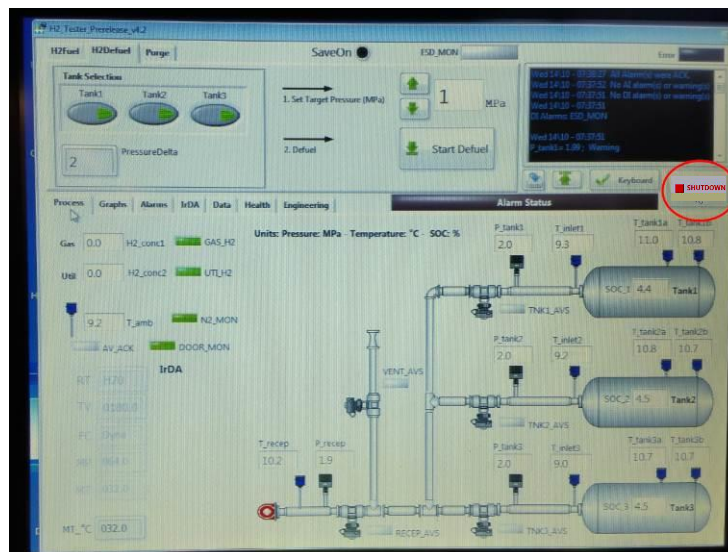


FIGURE 112 – CLOSING PROGRAM

8.5.4 Remote Vent Stack Disassemble Procedure

Follow the steps in Section 6.2.1 in reverse order to disassemble the vent stack. Then follow the procedures below to correctly store the components inside the trailer:

1. Place sections 2 and 3 into the bracket as shown below



FIGURE 113 – VENT STACK SECTIONS 2 AND 3 INSIDE TRAILER

2. Tighten the clamp onto the vent sections to secure in place



FIGURE 114 – TIGHTENING BRACKET ONTO VENT SECTIONS 2 & 3

3. Loosen the clamp on the left hand side and rotate so it is oriented vertically



FIGURE 115 – LOOSENING CLAMP FOR VENT SECTIONS 1 AND 4

4. Place vent sections 1 and 4 inside brackets and tighten clamp onto them (note clamp only will tighten properly when in one orientation)



FIGURE 116 – TIGHTENING CLAMP ONTO VENT SECTIONS 1 AND 4

5. Check that the bottom of the vent stack base (section 1) is not touching the floor. If it is, loosen the clamp, raise the section slightly and then tighten the clamp again.



FIGURE 117 – KEEP BOTTOM OF VENT SECTION 1 SLIGHTLY ABOVE THE FLOOR

6. Wrap a bungee cord (provided in tool chest) around vent section 1 (vent stack base) to prevent motion of the tri-pod style legs.



FIGURE 118 – WRAP BUNGEE CORD AROUND VENT STACK BASE TO MINIMIZE VIBRATION

7. The vent stack is now ready for transport

8.5.5 Transport Preparation Procedure

8.5.5.1 Nitrogen System Preparation

The following procedure should be followed to prepare the Nitrogen system for transportation:

1. If transporting nitrogen T or K cylinders with the device, use the provided ratchet straps to tighten the nitrogen cylinder in-place and prevent vibration (see Figure 119).



FIGURE 119 – STRAP NITROGEN CYLINDERS PRIOR TO TRANSPORT

2. Close all the valves and regulators on the nitrogen panel
3. Close the nitrogen tank valve
4. Open the nitrogen bleed valve to vent the pressure in the hose
5. Use the wrench provided to remove the CGA connection between the hose and the nitrogen tank
6. Remove the Swagelok fitting between the nitrogen hose and the bulkhead fitting on the N2 panel
7. Install a plug on the bulkhead fitting to prevent debris entry
8. Install protective cap to the top of the nitrogen cylinder
9. Stow the nitrogen hose in the tool chest

8.5.5.2 Hydrogen System Preparation

1. Check that the defuel flow control valve and defuel regulator are fully closed
2. Visually check that TPRD and Rupture disk vent stack caps are installed

3. Coil the hydrogen vent hose and place on the hook with the electrical cord

8.5.5.3 Additional Preparation

1. Unplug electrical cord, pull entire cord through bulkhead, coil onto hook and secure, close electrical bulkhead cover (fully)



FIGURE 120 – COIL ELECTRICAL CORD AND SECURE (LEFT), FULLY CLOSE ELECTRICAL BULKHEAD COVER (RIGHT)

2. Place sandbags, cable trays, safety cones into their respective storage locations.
3. Remove grounding cable and stow inside utility room with other grounding cables



FIGURE 121 – GROUNDING CABLE STORAGE (LEFT), UTILITY ROOM READY FOR TRANSPORT (RIGHT)

4. Check that roof top vent is closed
5. Make there are no tools or parts loose in the trailer
6. Lock the tool chest

7. Close the operator panel door, make sure the intrinsic wiring boxes and valve override box are closed
8. Hitch HyStEP to the tow vehicle using the reverse of the procedures outlined in Section 6.1.
9. Remove wheel chocks and place in sandbag storage area
10. Fully close doors, and operator panel door and lock

9 MAINTENANCE & CARE

9.1 MAINTENANCE SCHEDULE

The maintenance schedule for the device is shown below:

Component / Test	Minimum Service Interval	Requirements/Components
Trailer		
Tire Pressure	Before every trip	Inflate all tires to the proper pressure, visually inspect tires
Wheel lugs, nuts, & bolts	Before every trip	Tighten to proper torque specifications (displayed on front left side of trailer)
Coupler ball	Before every trip	Check for unusual wear, sufficient lube and lock mechanism
Safety chains and hitch ball	Before every trip	Check for unusual wear on chain links and hitch ball
Coupler	Before every trip	Check the safety pin to make sure its fastening properly
Brakes	Before every trip	Check operation and proper adjustment
Breakaway battery and switch	Before every trip	Check the battery in the breakaway system regularly
Doors and vent	Before every trip	You must close all doors (including operator panel door) and vent before travel
Lights	Before every trip	Replace spent bulbs and fix any broken lights
Load distribution	Before every trip	Make sure cargo weight is properly distributed
Welds	Every 3 months or 3,000 miles	Check welds for cracking and separations
Hinges	Every 3 months or 3,000 miles	Lubricate with light oil
Tie downs, E-track, and D-rings	Every 3 months or 3,000 miles	Check to make sure the hardware has no cracks and is fastened tight
Weatherproofing	Every 3 months or 3,000 miles	Check caulking on trailer roof, around rooftop vent, TPRD vent, burst disk vent, cellular modem, doors, operator panel and lights. Apply caulking to seal any areas where weatherproofing has been cracked or damaged.
Hub/Drum	Annually or every 12,000 miles	Inspect for abnormal wear or scoring
Wheel Bearings and Cups	Annually or every 12,000 miles	Inspect for corrosion or wear. Clean and repack

Component / Test	Minimum Service Interval	Requirements/Components
Seals	Annually or every 12,000 miles	Inspect for leakage. Replace if removed
Suspension Parts	Every 6 months or 6,000 miles	Inspect for bending, loose fasteners and wear
Suspension Wet Bolts & Equalizers	Every 3 months or 3,000 miles	Grease
Extreme Duty Bushings	Every 3 months or 3,000 miles	Grease
Wheels	Every 6 months or 6,000 miles	Inspect for cracks, dents, or distortion
Tire condition	Every 3 months or 3,000 miles	Inspect for cuts, wear, bulging, etc.
Hydrogen System		
Rupture Disk	Monthly	Visual inspection to ensure safety head (housing) is secure and free from mechanical damage. With nitrogen pressure in the purge line, check that the vent cap (on the roof) remains in-place to ensure disk is sealed.
Rupture Disk	Annually	Replace rupture disk and inspect flange surface on safety head
Hydrogen vent hose	Monthly (NFPA 2)	Visually inspect and test for leaks
Hydrogen vent hose	Every 2 years	Replace hose
Pneumatically Actuated Valves (AVs)	Weekly	Check that the valve actuates when selected. Refer to troubleshooting section if valve does not actuate.
Hydrogen Filter	When the pressure drop across the filter exceeds 5 MPa	Replace filter element, inspect O-Ring seal and replace if necessary
Receptacle	As needed	Replace front O-ring as per procedures outlined in Appendix (Component Manuals Section)
Pressure Transducers	Monthly, or as needed	Zero pressure transducers when system is at atmospheric pressure (see Engineering Functional Tab section under "Offset")
Pressure Transducers	Annually	Remove pressure transducer from system and calibrate in a certified calibration facility
Thermocouple	Monthly, or as needed	Compare thermocouple readings with ambient temperature after system has been unused for several days. Replace thermocouple if error is unacceptable.
TPRD	Every 3 months or less	Visual inspection to ensure that the PRD housing and PRD heat shrink are secure and free from mechanical damage

Component / Test	Minimum Service Interval	Requirements/Components
TPRD	Every 3 years (36 months) or 58,000 km, whichever occurs first	Certification inspection by trained personnel who are certified in accordance with local authority. The PRD housing is to be fully inspected to ensure no damage. The heat shrink is to be inspected to ensure is intact and covering the four PRD housing holes. The PRD is to be leak tested with a liquid leak detection fluid.
Hydrogen Tank	After a motor vehicle accident or fire and at least every 36 months or 36,000 miles whichever comes first	Visual inspection for damage or deterioration.
Tank brackets	After a motor vehicle accident or fire and at least every 36 months or 36,000 miles whichever comes first	Inspect bracket tension and rubber isolator condition.
Tank brackets	Annually, or as needed	Check the torque on hydrogen tank bracket bolts (the bolts with springs on them). Torque should be 25 ft.-lbs. If it is lower make note of it in a maintenance log and tighten to this value.
Hydrogen & Nitrogen Frame	Annually, or as needed	Check that the 6 bolts on the hydrogen rack and the 2 bolts on the nitrogen rack are torqued as specified. Bolts are marked to show the right position. If bolts have loosened, make note of it in a maintenance log, notify the owner representative, and tighten to the marked point.
Hydrogen & Nitrogen Frame	Annually, or as needed	Check for scratches where there is exposed steel and sand/re-paint any damaged areas to prevent rusting.
Hydrogen Piping	Weekly, or as needed	Visually inspect pipe, valves and fittings
Hydrogen Piping	Every 3 months or as needed	Perform leak test on pipe, valves and fittings
Pressure regulators	As required	See procedure in Component Manual section of Appendix
Vent Systems	As needed after weather event or vent cap removal	Inspect water drain device for water accumulation, check that caps are installed securely on vent stack outlets
Vent Systems	Annually	Visual inspection of vent system for obstructions and support integrity
Nitrogen System		
Nitrogen hose	Monthly (as per NFPA 2)	Visually inspect and test for leaks
Nitrogen hose	Every 2 years	Replace hose

Component / Test	Minimum Service Interval	Requirements/Components
Nitrogen filter	As needed	Replace filter element, inspect O-ring and replace if required
Nitrogen Piping	Weekly, or as needed	Visually inspect pipe, valves and fittings
Nitrogen Piping	Monthly, or as needed	Perform leak test on pipe, valves and fittings
Gas Detection		
Gas Detector	Daily	Verify a display reading of zero
	Monthly	Test detector using calibration gas (follow procedures outlined in Gas Detector Manual page 37)
	3–6 months	Calibrate gas detector using procedures outlined in Gas Detector Manual

9.2 PREPARATION AND PRECAUTIONS

Prior to conducting maintenance, follow the following precautions:

- Ensure the system is in a safe state, and all forms of energy are isolated. Forms of energy include:
 - Electrical
 - Pneumatic, make sure system is at atmospheric pressure before adjusting any hydrogen or nitrogen fittings
 - Gravitational potential energy, make sure wheel chocks are in place and trailer will not roll prior to doing any work inside the trailer or underneath the trailer

9.3 FILTERS

9.3.1 Hydrogen Filter

To replace the hydrogen filter, follow the procedures shown in the “Operation and Installation Instructions” which are provided by Headline Filters (see Appendix, Component Manual Sections).

- To access the filter, remove the lower sheet metal panel from the front side of the tank frame using the tools provided in the tool chest (see Figure 124). The filter will be on the right side while looking towards the back of the trailer.
- There are 2 spare filter elements provided in the tool chest
- When removing the filter bowl, use caution to make sure the O-Ring is not damaged.

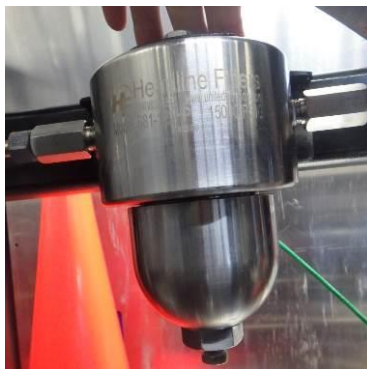


FIGURE 122 – HYDROGEN FILTER

9.3.2 Nitrogen Filter

To change the nitrogen filter, follow remove the bowl on the bottom of the filter following the procedures provided on the filter kits provided. The filter has a Swagelok® part number SS-6TF-4K-2.

- Nitrogen filter is located on the back side of the nitrogen panel, behind the purge flow control valve
- There are 6 spare filter element kits provided with the HyStEP.
- When removing the filter bowl, use caution to make sure the O-Ring is not damaged.

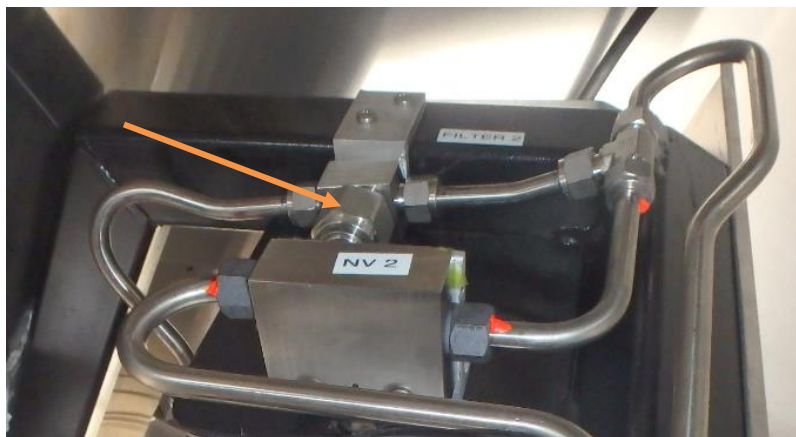


FIGURE 123 – NITROGEN FILTER

9.4 GAS SENSOR

For gas sensor maintenance procedures, see the manufacturers manual located in the “Component Manual” section of the Appendix

9.5 THERMOCOUPLE

Follow the procedure outlined in the Maintenance Schedule. When inspecting, check the condition of the thermocouple cable. Thermocouples must be replaced if there is error in the readings.

9.6 PRESSURE TRANSDUCER

Follow the procedure outlined in the Maintenance Schedule. Check the condition of the cable when inspecting the transducer.

9.7 PRD VENT SYSTEM

If the caps are missing from the TPRD vent stack or the Burst Disk vent stack the following procedure must be followed:

9.7.1 TPRD Vent Stack:

1. Install a new cap (provided in tool chest) on the vent stack outlet and monitor it for approximately half an hour when there is pressure in the tanks. If the cap doesn't pop off, proceed to 2. If it does, there may be a leak through the TPRD. Complete the TPRD maintenance outlined in the maintenance schedule.
2. If the cap remains on the vent stack outlet, check for water entry into the vent stack by:
 - a. Remove the lower sheet metal panel from the front side of the tank frame using the tools provided in the tool chest (see Figure 124).



FIGURE 124 – LOWER SHEET METAL PANEL REMOVED

- b. Locate the TPRD Vent Stack on the left side of the cylinders (while facing the back of the trailer and inside the utility room).

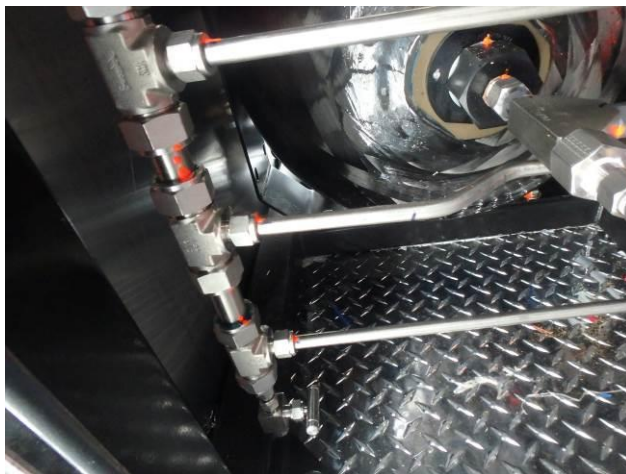


FIGURE 125 – TPRD VENT STACK

- c. Ensure the needle valve at the bottom of the vent stack is closed (turn clockwise), and then remove the plug from the needle valve outlet.
- d. Open the needle valve and make note of the quantity of water drained.
- e. Once drained, close the needle valve and re-install the plug and the sheet metal panel.

9.7.2 Rupture Disk Vent Stack:

1. Install a new cap (provided in the tool chest) on the vent stack outlet and monitor it for approximately half an hour with the nitrogen purge system pressurized. If the cap doesn't pop off, drain water out of line using the procedure in the following section. If it does, the rupture disk may have been activated or there could be a leak through the system. Follow the same procedure as to drain the water but inspect and replace the rupture disk.



Caution: Replacing Rupture Disk and removing high pressure fittings to access burst disk or drain water **MUST** only be done by authorized personnel.

2. Vent nitrogen system pressure down to atmospheric pressure. The pressure on the burst disk inlet will be shown on the Nitrogen Purge Pressure gauge (PI 7).
 - a. Hydrogen lines will have to be at atmospheric pressure in order to completely vent the nitrogen line
3. To drain water from rupture disk vent:
 - a. Loosen the Swagelok® tube fitting from the top of the rupture disk (Swagelok® approved procedures)

- b. Let water drain out from line, may need to loosen the bulkhead fitting on the roof and the mounting brackets upstream of the rupture disk
- c. Remove the Swagelok® tube fitting from the bottom of the rupture disk
- d. Remove rupture disk safety head and drain the remaining water from it
- e. If rupture disk inspection is not required, re-install following the same steps but in reverse



FIGURE 126 – RUPTURE DISK

4. If rupture disk inspection is required, open the safety head following the procedures from BS&B shown in the component manual section of the Appendix. Then replace/inspect the device.
5. Re-install following the same steps but in reverse
6. Re-pressurize the system, and purge all hydrogen lines with nitrogen as per the procedures outlined in this manual
7. Seal the joint on the roof where the vent stack exits using the sealant provided in the tool chest

9.8 HYDROGEN TANK

Perform maintenance as outlined in the Maintenance Schedule. Safety and maintenance guidelines provided by Quantum are outlined below:



Note: When the hydrogen tanks are below 2 MPa, the liner contracts and allows a cavity to open up between the liner and the composite. Tank leakage has occurred when re-pressurized from low pressures, which seals up after being pressurized.

Do:

- Inspect the tanks after a collision

- Preform regular leak inspections on high pressure lines every three months.

Do Not:

- Fill to a pressure greater than 87.5 MPa (12,691 psi)
- Fill the tanks if the tank pressure is less than 2.0 MPa (290 psi) AND the tank temperature is less than -20C (-4F)
- Modify or tamper with the tanks
- Remove the tanks without first defueling

9.9 TRAILER

The following procedures should be followed to maintain the performance and integrity of the trailer.

BRAKES:

Your trailer brakes must be inspected and serviced every 3,000 miles or once a year. Remember the more you use it the more you will want to have your brakes checked. If you are not sure about anything, remember to look at your Axle Manufacturer's Service Manual.

COUPLER:

Check your coupler before every trip. Look to see if there are any cracks and that the locking mechanism is in proper working order.

FRAME MAINTENANCE:

Over time, road use will begin to chip away at the factory-protected underside of your trailer. This is where trailers receive the most punishment. Gravel, rocks, and any loose road debris are thrown up and hit the bottom of your trailer. You need to check the underside of your trailer at least once a year or every 3,000 miles. If you notice any bare spots, please touch-up with an automotive undercoating or matching frame paint.

LUG NUTS:

Check lug nut tightness before your first trip and after 50 miles, 75 miles, and 150 miles. You will want to recheck at least every 3 months or 3,000 miles.

WELDS:

Please check your welds every 3 months or 3,000 miles for any cracks or fractures. If you notice any cracks or fractures, please contact your Forest River dealer immediately.

MAINTENANCE RECORD:

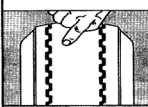
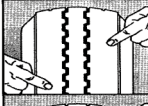
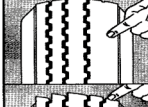
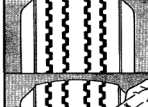
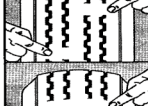
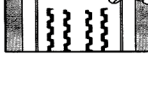
There is a maintenance record at the back of this manual. Please use this record book to keep track of all the work you do on your trailer. It will help keep your trailer in the best shape possible.

TIRES AND WHEELS:

Always check your tire pressure before using your trailer. When checking tire pressure, always check when tires are cold. If you are not sure of proper pressure, you can find it on the sidewall of your tires. DO NOT change your tire pressure for the load of the trailer. If you do, it can cause excessive tire wear and even a blowout.

Tire Inspection

WARNING When replacing tires consult wheel and tire manufacturers' specifications for compatibility. Improperly matched wheels and tires may fail and cause property damage, serious personal injury, or loss of life.

	Condition	Possible Cause	Remedy
	Even Center Wear	Over Inflation	Check & Adjust Pressure When Cold
	Inside & Outside Wear	Under Inflation	Check & Adjust Pressure When Cold
	Smooth, Side Wear - One Side	Loss of Camber or Overloading	Check & Unload As Necessary Have Alignment Checked
	"Feathering" Across The Face	Axle Not Square To Frame or Incorrect Toe In	Square Axles Have Alignment Checked
	Cupping	Loose Bearings or Wheel Balance	Check Bearing Adjustment and Wheel & Tire Balance
	Flat Spots	Wheel Lockup	Adjust Brakes

WHEELS:

Wheels should be washed and waxed periodically. Aluminum rims have a clear coat on them so they will last longer through harsh conditions. Make sure you use a very gentle cleaning compound so it will not hurt your rims. Never use any cleaner that contains lye or is acid-based. If you use a lye- or acid-based cleaner, it will ruin the finish of your rims.

DOORS:

Check your door hinges every 3,000 miles or 3 months. If your trailer has a ramp door, please do not attempt to adjust the ramp cable or spring. All repairs or adjustments must be performed by experienced door service personnel only. **WARNING:** The spring-assist on ramp doors can cause serious injury or death.

EXTERIOR ALUMINUM SKIN:

Please treat the outside of the trailer as you would your car. Use mild soap when washing, and if you desire to wax, use an automotive-type wax. Proper care and maintenance will ensure your trailer's color and the durability of its finish.

FLOOR:

To keep your floor in tip-top shape, avoid prolonged exposure to water. For example, the snow and ice melting off your snowmobile, ATV, or automobile could cause floor damage. To make your floor last longer, you could paint it with an oil-based enamel. This would not only add protection, but would also help aid in cleaning up spills.

ROOF:

Inspect your roof at least once a year. If you live where heavy snow conditions exist, do not let ice and snow build up on your roof. Do not haul items on your roof if you do not have

ROOF RACKS.

9.10 LEAK CHECK & PRESSURE TEST

It is good practice to leak check the hydrogen and nitrogen system regularly. With a pressurized system, the operator should check every fitting in the hydrogen system with a handheld hydrogen gas detector. For the nitrogen system, the components should be checked with a liquid leak detector or another equivalent leak detection method. Leak checks should be performed at least every 3 months.

To leak check the system the following tools are required:

- A calibrated, handheld hydrogen gas detector
- A liquid leak detector such as Swagelok® Snoop®

If a leak is found at a fitting, authorized and trained personnel must repair the leak using methods approved by the component manufacturer. Details on each fitting are shown on the P&ID drawing along with the Mechanical Bill of Materials (drawings PL-00742-04-02 and PL-00742-04-03).

The HyStEP device had a leak check and pressure test conducted by the manufacturer prior to shipment of the device. Certificates showing this are shown in the Appendix.

9.11 SPARE PARTS AND TOOLS

The following is a list of the spare parts and tools provided with the HyStEP Device:

1. Dual Point Temperature Probe (x1)
2. CAT5E Internet Cable (x1)
3. Spare Tie-down Strap for Nitrogen Cylinder (x1)
4. Pressure Gauge, Swagelok PGI-63C-MG120-CA03-I (x1)
5. Low Pressure PRV for Instrument Nitrogen Line set at 125 psi (x1)
6. Caps for Rupture Disk Vent Stack (x5)
7. Caps for TPRD Vent Stack (x4)
8. Ball Valve, Swagelok SS-436S6 (x2)
9. Elbow, Swagelok SS-400-2-4 (x3)
10. Adaptor, Swagelok SS-400-1-4 (x3)
11. Adaptor for N2 Line Inlet, Swagelok SS-600-61 (x2)
12. NPT End for HIP Thermocouple Fitting (x1)
13. Tee 3/8", 1/4" branch, Swagelok SS-600-3-6-4 (x1)
14. Burst Disk (x2)
15. Filter Elements, High Pressure SS-12-57-03T (x2)
16. Filter Elements, N2 Low Pressure SS-8F-K4-2 (x6)
17. Electrical Cord Plug (x1)
18. Fuse GMA-5A (x5)
19. Fuse AGC-5 (x5)
20. Fuse GMA-3A (x5)
21. Fuse AGC-3 (x5)

- 22. SAE O-Rings
- 23. Rubber Mallet (x1)
- 24. Cable Tray (x10)
- 25. Sand Bags (x12)
- 26. Safety Cones (x12)
- 27. Gas Detector Calibration Kit (x1)
- 28. Wrench Set with Wrenches sized ¼” to 1” (x1)
- 29. Wrench 1-1/2” (x1)
- 30. Wrench 1-3/8” (x1)
- 31. Wrench 1-1/8” (x1)
- 32. Small Crescent Wrench (x2)
- 33. Large Crescent Wrench (x2)
- 34. Screwdriver, Multi-driver (x1)
- 35. Small Flat-Head Screwdriver (x1)
- 36. Socket and driver for Explosion Proof Box Bolts (x1)
- 37. Short N2 Hose (x1)
- 38. Tire Pressure Gauge (x1)
- 39. Polyurethane Caulking Tube (x1)
- 40. Set of Keys (x2)
- 41. Wheel Chocks (x4)
- 42. Miscellaneous Labels

10 TROUBLESHOOTING

This section contains helpful information on what to do when trouble arises with the HyStEP device. If the trouble does not go away after following the troubleshooting steps, record any changes/results of each and report to the system administrator or manufacturer for further information.

10.1 TOUCHSCREEN DOES NOT TURN ON:

- Make sure the HyStEP power cord is plugged in to a working 120VAC outlet.
- Check the LED lights at the back of the touchscreen monitor:
 - i. If you see a green light only, it indicates the unit is powered up and receiving proper video signal from cDAQ; This may indicate a burnt out screen and the unit may need repair or replacement.
 - ii. If you see both green and red lights, it indicates the unit is powered up but no video signal. This may be due to bad connection in the video cable; potentially at these three connections points (back of the touchscreen, Explosion-Proof J/B, Explosion-Proof Electrical Enclosure). Check the connections ONLY when there is no hydrogen in the system or the system is purged with nitrogen.
 - iii. If you see no lights at all, it indicates there is no power to the touchscreen. If the HyStEP is plugged into a working 120VAC outlet, check the fuses and/or 24VDC power supplies inside the Explosion-Proof Enclosure. Opening of any explosion-proof enclosures shall be performed ONLY when there is no hydrogen in the system or the system is purged with nitrogen.

10.2 TOUCH DOES NOT WORK:

- Make sure the screen is dry.
- If the screen is on but the touch is not working, try with a stylus.
- If the stylus doesn't work, try the keyboard/mouse.
- Restart cDAQ and repeat b & c.
- Check the USB cable. There may be bad connections in the USB cable; potentially at these three connections points (back of the touchscreen, Explosion-Proof J/B, Explosion-Proof Electrical Enclosure). Check the connections ONLY when there is no hydrogen in the system or the system is purged with nitrogen.

10.3 KEYBOARD/MOUSE DOES NOT WORK

- Make sure the on/off switch on the keyboard is turned on.
- Check the batteries and replace if needed.
- Move the keyboard/mouse close to the Explosion-Proof enclosure to see if it works again when in a closer range with the cDAQ. If so, it may indicate low battery level and/or electrical interferences.

10.4 PNEUMATIC VALVES DO NOT OPEN:

- Make sure the nitrogen supply pressure is above 90 psi and the manual shut-off valve is open.
- Check if there is an active alarm of the pneumatic valve in cDAQ. If so, acknowledge the alarm.
- Check if there is an ESD alarm in cDAQ. When ESD alarm is activated, the main solenoid will be de-energized to shut off the nitrogen supply to the individual solenoid valves.
- If accessible, check the mechanical position switches (spring up when valve open) of the pneumatic valve against the actual valve stem position (up to open).

10.5 PNEUMATIC VALVES DO NOT CLOSE:

- Note the pneumatic valve close when there is no or low pneumatic pressure.
- Check the “Engineering” tab to see if the valve is being overridden to open position.
- If accessible, check the mechanical position switches (spring up when valve open) of the pneumatic valve against the actual valve stem position (up to open).

10.6 AV ALARM STAYS ON CONTINUOUSLY/REPEATEDLY

- Check if there is an active alarm in cDAQ. If so, acknowledge the alarm.
- Press and hold the silence button (at least 3 sec) to see if the audible alarm can be turned off.
- Check the ESD circuit to see if it is activated by hardwired components such as heat detectors or gas detectors.
- Restart cDAQ application if safe to do so.

10.7 SILENCE BUTTON DOES NOT WORK

- Press and hold the silence button (at least 3 sec) to see if the audible alarm can be turned off.
- Restart cDAQ application if safe to do so.
- If audible alarm stays on and cannot be silenced after re-starting cDAQ, shutdown cDAQ and/or disconnect the electrical cord from the outlet.

10.8 AMBIENT TEMPERATURE ABNORMALLY HIGH

- If the HyStEP trailer has been exposed to sunlight, it may take a while for the ambient temperature sensor and other parts of the trailer to reach equilibrium temperature with the surroundings to provide accurate measure of the ambient temperature.
- Make sure the back of the trailer roof is away from direct sunlight, lights from reflective surface, or other heat sources such as lights.

10.9 HYDROGEN DETECTOR FALSE ALARM

- Acknowledge the alarm in cDAQ and silence the audible alarm.
- If the hydrogen detector is confirmed to produce false alarm (checked again other handheld hydrogen detector), calibrate the hydrogen sensors as per the procedures in the manufacturer's manual.

10.10 UNABLE TO CONNECT TO cDAQ LOCAL AREA NETWORK

- Check the CAT-5 cable connections and use a different one to confirm.
- Check your computer network setup and consult your IT department if needed
- Check the cDAQ Internet connectivity by opening a web browser in the HMI and serving the web.

10.11 UNABLE TO VIEW THE cDAQ OR DATA FOLDERS:

- If your computer is connected to the cDAQ local area network and unable to see the cDAQ computer, type the address <http://192.168.13.100> on the address bar of the Windows Explorer and the shared folder "H2_Data should show up.
- Open a command prompt in Windows and ping 192.168.10.13 to check the response from cDAQ.
- Contact your IT department or the HyStEP administrator if this does not resolve the issue.

10.12 INCONSISTENT PRESSURE TRANSDUCER READINGS

- Since pressure varies with temperature, let the HyStEP device settle with the surroundings and reach equilibrium with the ambient temperature when checking the pressure transducer readings.
- If the accuracy of a pressure transducer is in doubt, one way to confirm is to open up all pneumatic valves to equalize the pressure throughout the system. Compare the readings of all pressure transducers and apply offsets if the actual system pressure is known. Note the differential pressure among tanks must be within 2MPa and you need to the password for the “Engineering” Tab in order to apply offsets.
- If applying offsets do not improve the accuracy, calibrate the pressure transducers.

10.13 INCONSISTENT THERMOCOUPLE READINGS

- Let the HyStEP device settle with the surroundings and reach equilibrium with the ambient temperature when checking the thermocouple readings.
- If the accuracy of a thermocouple is in doubt, one way to confirm is to let the HyStEP device settle with the surroundings and reach equilibrium with the ambient temperature. Compare the readings of all thermocouple and apply offsets if desired. Note you need to the password for the “Engineering” Tab in order to apply offsets.
- If applying offsets do not improve the accuracy, replace the faulty thermocouple.

10.14 DOOR MONITOR ALARM

- The back doors to the gas room shall remain open during operation and there is mechanical position switch mounted on the top to monitor the door status.
- If the door is open and alarm remains active, check the mechanical position switch to see if it is stuck in close position.
- If the alarm is intermittent, it may indicate the door is swinging back/and forth. In this case, open the door and latch it in place.
- If this is not the case, replace check electrical connections, and/or replace switch.

10.15 SYSTEM SHUTDOWN DURING DEFUELING:

- If an ESD alarm occurs during defueling, check the tank temperature. The system will shutdown if any of the tank temperatures are below -40°C.

- In such cases, acknowledge the alarms and wait until the tank warms up to a higher temperature.
- Also, this may indicate the defueling rate is too high. Adjust the defueling rate by closing the defuel needle valve at the operator panel to achieve an optimal defueling rate (approximately 0.1MPa decrease every 3 seconds).

10.16 NITROGEN NOT FLOWING INTO TANK DURING PURGING

- Make sure “Open Tank(s)” on cDAQ is pressed and pneumatic valves are green indicating they are open.
- Make sure the hand valves in the nitrogen panel are open.
- Check the pressure gauge and regulator to make sure the instrument nitrogen supply pressure is at 95 psi.

10.17 HYDROGEN NOT FLOWING OUT OF TANK DURING DEFUELING

- Check the vent stack is installed and the quick connections at each end of the hose are properly installed
- Make sure “Start Defuel” on cDAQ is pressed and the pneumatic valves of the receptacle, the vent, and the selected tank(s) are green indicating they are open.
- Make sure the hand valves at the tank inlet are fully open.
- Check the pressure gauge and regulator to make sure defuel line pressure is at about 3-4 MPa.
- Make sure the defuel needle valve is open.

10.18 HYDROGEN NOT FLOWING TO REMOTE VENT STACK

- Perform the tasks in 10.18
- Check the connection of the hose at both ends and at the interconnections.

10.19 PRESSURE REGULATOR RESONATING

- Typically due to the defuel pressure regulator being set at too low of a pressure.
- Adjust the pressure regulator to between 3 to 4 MPa
- Use the defuel needle valve to adjust the defuel rate to about 0.1 MPa drop every 3 seconds.

10.20 UNABLE TO DISCONNECT THE HYDROGEN VENT HOSE

- Pressure still exists in the line defuel line
- De-pressurize the line to just above atmospheric pressure

10.21 PURGING THE SYSTEM VENTS NITROGEN OUT THE TRAILER VENT STACK

- Rupture disk has burst
- Replace as per manufacturers requirements and the procedures shown in the Maintenance section.

10.22 WHILE ASSEMBLING VENT STACK, SWAGELOK FITTINGS “BOTTOM OUT”:

- The 1” Swagelok coupler has been disconnected & reconnected the maximum number of times
- Replace the coupler

11 APPENDICES

11.1 LIST OF SUPPORTING DOCUMENTATION

Below is a list of the supporting documentation to this manual. Appendix items are included in the proceeding pages of this manual, (hard copy) or in separate folders (electronic copy).

1. Mechanical Drawing Package, Includes:
 - a. Mechanical Drawing Index
 - b. Trailer Layout
 - c. Hydrogen & Nitrogen Rack
 - d. Hazardous Area Drawing
 - e. Process Flow Diagram
 - f. Process and Instrumentation Diagram (P&ID)
 - g. Detailed Process and Instrumentation Diagram (with references to BOM)
 - h. Mechanical Bill of Materials (BOM)
2. Electrical Drawing Package, Includes:
 - a. Electrical Drawing Index
 - b. Trailer Electrical Equipment Layout
 - c. System Schematic
 - d. Electrical Power Distribution
 - e. Explosion-Proof Enclosure Layout
 - f. DAQ System & Network Layout
 - g. DAQ Points List
 - h. DAQ Module 1 DI/DO Wiring Details
 - i. DAQ Module 2 AI Wiring Details
 - j. DAQ Module 3 TT Wiring Details
 - k. DAQ Module 4 DO Wiring Details
 - l. Fire Detection Wiring Details
 - m. Gas Detection Wiring Details
 - n. Emergency Shutdown (ESD) Circuit Wiring Details
 - o. Pneumatic Control System Schematic
 - p. Intrinsic Safety Device Schedule
 - q. Bill of Electrical Materials
3. Alarm Matrix
4. Certificates and Calculations
 - a. Pressure Test Certificate
 - b. Trailer Certificate
 - c. Hydrogen Rack Finite Element Analysis (for DOT Permitting)
 - d. Calculation of Radiant Heat Intensity from Remote Vent Stack
5. Software & Description
6. FMECA Documentation and Summary
7. Component Information
 - a. Component Certifications
 - b. Component Datasheets
 - c. Component Manuals