



Product Manual

LH2 ST18600 Transport Trailer



Designed and Built by:

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Revision Log

Revision Level	Date	Description
A	12/6/2022	New Manual Creation
B	04/28/2023	Content Update

Preface

General

This manual is an important reference tool - keep it with the trailer at all times. The purpose of this manual is to provide owners, operators, and service technicians with the precautions and operating procedures essential for the safe and proper trailer operation.

All information in this manual should be read and understood before any attempt is made to operate the trailer. This manual is a supplement to and not a replacement for your organization's internal safety procedures. Always follow organizational policies and procedures. Proper safety practices are the responsibility of the owners, users, operators, and service technicians.

All instructions in this manual are based upon the use of the trailer under proper operating conditions, with no deviations from the original design. Any alteration or modification of the trailer is strictly forbidden without written approval from Chart Inc.

Reporting Safety Defects

If you believe that your vehicle has a defect which could cause a crash or could cause injury or death, you should immediately inform the National Highway Safety Administration (NHTSA) in addition to notifying Chart Inc.

If NHTSA receives similar complaints, it may open an investigation, and if it finds that a safety defect exists in a group of vehicles, it may order a recall and remedy campaign. However, NHTSA cannot become involved in individual problems between you, your dealer, or Chart Inc.

To contact NHTSA, you may call the Vehicle Safety Hotline toll-free at 1-888-327-4236 (TTY: 1-800- 424-9153); go to <http://nhtsa.safercar.gov>; or write to: Administrator, NHTSA, 12000 New-Jersey Avenue SE, Washington, DC 20590. You can also obtain other information about motor vehicle safety from <http://www.safercar.gov>.

Non-disclosure Agreement

The design of this trailer and contents of this manual are the intellectual property of Chart Inc. and protected by various non-disclosure agreements between Chart, customers, and subsidiaries of both companies. Disclosure of any information contained herein is expressly prohibited subject to the terms and conditions of the non-disclosure agreements. Individual employees may be held personally liable for such prohibited disclosures.

Acronyms / Abbreviations

The following acronyms / abbreviations are used throughout this manual:

ASME	American Society of Mechanical Engineers	UV	Ultra-compact Valve (Pneumatic-Actuated)
BAR	Metric Unit of Pressure	VAC	Voltage - Alternating Current
BARG	Metric Unit of Gauge Pressure	VDC	Voltage - Direct Current
CGA	Compressed Gas Association	VFD	Variable Frequency Drive
CP	Connection Point	VJ	Vacuum Jacket
DOT	Department of Transportation		
GPM	Gallons Per Minute		
HV	Hand-operated Valve		
LH ₂	Liquid Hydrogen		
LI	Level Indicator		
LN ₂ /LIN	Liquid Nitrogen		
LOX	Liquid Oxygen		
LPM	Liters Per Minute		
MAWP	Maximum Allowable Working Pressure		
NER	Normal Evaporation Rate		
NIST	National Institute of Standards and Tech		
NPSH	Net Positive Suction Head		
OEM	Original Equipment Manufacturer		
PB	Pressure Builder		
PCV	Pressure Control Valve		
PI	Pressure Indicator		
PN	Part Number		
PSI	Pounds per Square Inch		
PSIA	Pounds per Square Inch Absolute		
PSIG	Pounds per Square Inch Gauge		
PSID	Pounds per Square Inch Differential		
PTO	Power Take-Off		
P&ID	Piping & Instrumentation Diagram		
RV	Relief Valve		
RTD	Resistance Temperature Device		
SS	Stainless Steel		
UT	Ultrasonic Testing		

Terms

Throughout this manual safety precautions will be designated as follows:



Warning! *Description of a condition that can result in personal injury or death.*



Caution! *Description of a condition that can result in equipment or component damage.*



Note: *A statement that contains information that is important enough to emphasize or repeat.*

Safety

Safety Summary

Although safety features have been installed to aid in safe operation and maintenance of this system, it is essential that all personnel having contact with this equipment become thoroughly familiar with all safety precautions and procedures contained in this manual. Personnel operating LH₂ (Liquefied Hydrogen) systems should review all laws, rules and regulations pertaining to the use of LH₂. Personnel must also be knowledgeable of the properties of LH₂ and the safety equipment required for handling LH₂.

The safety of personnel and equipment is the responsibility of the customer. The instructions and guidelines provided within this manual are only recommendations. Personnel should refer to the safety procedures and policies of their company.

General LH₂ Safety

It is recommended that all personnel involved with the handling of LH₂ should be familiar with the characteristics of both the liquid and the gas produced. The potential hazards in handling LH₂ stem mainly from three important properties:

- **LH₂ is an Extremely Cold Liquid** – At atmospheric pressure, depending upon composition, LH₂ boils at about -252°C.
- **A Small Quantity of Liquid Converts into a Large Volume of Gas** – One volume of LH₂ produces approximately 845 volumes of gas.
- **Flammability**– Hydrogen is extremely flammable. At ambient conditions the flammable mixture range with air is from 4% to 75% gas by volume.

Hydrogen, Refrigerated Liquid	
DOT UN Number	UN1966
Transport Hazard Class	2.1
Label	Flammable Gas

This equipment contains pressurized LH₂ at cryogenic temperatures. The major components in the system generally

consist of pressure-containing components (such as a vessel and pipes) encased within outer steel vacuum shells. The

pressure vessel operates under medium pressure at extremely low temperatures. Personnel operating this equipment must always adhere to the safety precautions included in the section.



Warning! *NEVER use components (valves, gauges, fittings, etc.) or piping as steps or footholds. Always use appropriate equipment to access components for maintenance or repair.*

Wear Appropriate Clothing and Protective Gear

Accidental contact of LH₂ with skin or eyes may cause a freezing injury similar to a burn. Personnel must wear the appropriate clothing and protective gear while working around the equipment, especially when making or breaking connections. Do not allow liquid to splash, spill or leak. Protect eyes and cover skin wherever the possibility of contact with liquid, cold equipment or cold gas exists. Use clean, easily removable insulated gloves and long sleeves for arm protection. Cuff-less trousers should be worn over the shoes to allow spilled liquid to be shed away from the Operator's body.

Wear the following items whenever working on this equipment:

- Safety Glasses
- Clean Insulated Gloves
- Long-sleeved Shirt
- Cuff-less Trousers
- Appropriate Shoes
- Harnesses and Retrieval Lines (if entering confined spaces)
- Flame Resistant Clothing
 - Face Shield
 - Apron

Keep Away from Flame or Spark

Hydrogen is flammable. All general-purpose electrical equipment (e.g. cellular phones, etc.) is prohibited in areas

where LH₂ is stored or handled. LH₂ must be stored and

transferred under positive pressure to prevent the infiltration of air or other gases. Keep LH₂ equipment away from open flames or electrical sparks. Never permit smoking in areas where LH₂ equipment is repaired, used or stored.



Warning! Due to the flammable properties and the risk of asphyxiation, LH₂ must never be stored in confined areas or areas unsuitable for LH₂ storage. Always exercise caution when storing LH₂ containers or parking LH₂ vehicles.

Remove Excess Pressure and Liquid

This equipment is a pressurized system. LH₂ will boil and build up pressure in the system. Isolate the affected section and empty the section of liquid before removing parts or loosening fittings. Always remove parts and fittings in a safe manner. Working on a pressurized section in an unsafe or careless manner can cause serious injuries, or even death. External valves and fittings can become extremely cold and can cause painful burns to personnel who are not adequately protected. Always empty LH₂ and remove pressure from the system before removing any parts or components.



Caution! DO NOT trap LH₂ between two shutoff valves without a relief device to protect piping. Trapped LH₂ can vaporize and rapidly increase pressure, causing pipes to burst.

Vessel Safety

Intended Use

This LH₂ transport trailer is designed for transportation and delivery of liquid hydrogen, along with incidental storage. The trailer is filled with liquid hydrogen at a fill plant, transported to one or more delivery sites, and liquid hydrogen is delivered by pressure transfer, with pressure built and maintained at a safe-level by the on-board vaporizer (pressure building coil). This trailer should never be used to transport liquid hydrogen at a pressure in excess of DOT regulations nor to build pressure above its MAWP. Further, the trailer is intended for operation only by trained professionals and in accordance with CFR. While the liquid hydrogen transport trailer may be used for occasional or incidental storage of product, please note the NER and corresponding boil-off and pressure rise rates when determining the feasibility of storage and associated impact on product delivery (including loss of deliverable product).

This trailer must not be used for any purpose other than described herein due to the risk of injury (including fatal injuries) or property damage to the trailer and any nearby equipment. Neither the manufacturer nor their associated firms or employees can be liable for any damages resulting from improper utilization of this liquid hydrogen transport trailer.

Tank Safety Components



Note: The tank safety components in the following illustrations are denoted with purple boxes.

Trailer Line Safeties

Multiple line safeties are installed on the Trailer.

- Trailer Line Safeties will open to vent if the pressure in the adjacent line exceeds 225 psig.

Damaged Vessels

Cryogenic vessels are at times exposed to unforeseen catastrophic environmental and ecological conditions. Extra caution must always be taken whenever a cryogenic vessel is involved in an incident compromising the vessel or its safety devices. Always exercise extreme caution whenever a vessel has been exposed to extreme heat, fire, or exposed to adverse weather and ecological conditions (earthquakes, tornadoes, hurricanes, etc.).

Always exercise extra caution if a vessel is suspected of abnormal operation. In the case of known or suspected vessel vacuum problems (even if extraordinary circumstances such as those noted above have not occurred), do not continue to use the unit. Continued use of a cryogenic vessel that has a vacuum problem can lead to more severe conditions, including the vessel becoming brittle and cracking. The outer steel jacket may rupture due to inordinate stress conditions caused by an internal liquid leak.

Carefully empty contents from a damaged or suspect vessel as soon as possible. Never, under any circumstances, leave product in a damaged vessel for an extended period. Do not refill a damaged vessel until it is repaired and re-certified. It is strongly recommended that damaged vessels be evaluated by trained Chart technicians prior to returning the vessel into service.

Design Modification

- DO NOT use this trailer in a manner inconsistent with the instructions outlined in this manual.
- DO NOT alter the trailer design or perform any service inconsistent with the instructions outlined in this manual without the prior written approval of Chart Inc.
- ALWAYS use replacement parts authorized by Chart Inc. when replacing parts and components.

Operator Qualifications

Chart hydrogen trailers are designed for safe and simple operation. Operators are expected to be knowledgeable regarding the nature of the gas(es) with which they are working, as well as all applicable safety requirements. This manual contains several sections dealing with operating instructions, handling instructions and maintenance procedures. To fully understand these procedures, we recommend that Operators and Maintenance Personnel first become familiar with the system controls and indicators.

Manufacturer Liability Statement

The manufacturer believes the information presented in this manual to be accurate and up to date and assumes no liability concerning use of information contained herein by any party. The information contained herein is not a recommendation to violate federal, provincial, state, or municipal laws or regulations.

Introduction

General Precautions

Cryogenic liquids, even in large quantities can be safely transported, handled and stored. Safe handling practices are based on an understanding of the specific properties of the cryogenic liquid to be handled and knowing the liquid's material compatibility. The Compressed Gas Association (CGA) Publication, P-12 - Safe Handling of Cryogenic Liquids, provides recommended procedures for the handling of the most common cryogenic liquids.

Cryogenic liquids are extremely cold. Cryogenic liquids have a normal boiling point below -130°F according to National Institute of Standards and Technology (NIST) Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. The cryogenic liquids and their cold boil-off vapors can rapidly cause frostbite. The cold piping in the rear compartment or pressure building coil on a liquid hydrogen trailer can reach below the boiling point of liquefied air, -318°F, and can condense the surrounding air into liquid. This liquid air can quickly create an oxygen rich environment and the safety precautions for such an environment must be followed. Liquid Hydrogen is also flammable and should be handled accordingly.

Personal Protective Equipment is required to operate this trailer. Safety glasses with side shields, along with a hardhat and face-shield should always be worn. Insulated gloves when handling anything that comes in contact with cryogenic liquids and vapors. Gloves should be kept free of oil and grease and if contaminated, should be discarded. Appropriate flame-resistant clothing shall be worn that meets the standards of NFPA 2112, Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire.

Terminology of Cryogenics

States of Matter

Matter can exist as a gas, liquid, or a solid. Two phase liquid is a liquid with gas bubbles or slugs of gas due to lack of pressure (subcool) to maintain equilibrium. Gas and liquid can exist at a range of temperatures.

Saturation

Defined as the point at which liquid and vapor coexist at the same pressure and temperature.

Liquid density, temperature, and equilibrium pressure change

with the saturation condition of the liquid. Saturation can also be described as an energy state. Liquid molecules at a higher energy state (warmer) take up more space, which is often referred to as liquid growth.

Equilibrium

In a closed vessel the gas and liquid temperatures are the same. If there is a temperature difference between the gas and liquid (with the tank closed), the gas and liquid will change their temperatures until they are equal. In stationary tanks, stratification can take place, creating a temperature gradient across the liquid and vapor. However, the temperature at the liquid-vapor interface is the same for both.

Saturation Pressure

Pressure (usually in psig) that is used to describe the current saturation condition of a liquid and gas within a closed container.

Vaporization

Changing liquid into vapor by warming the liquid for the purpose of subcooling or for gas use.

Vapor Pressure

Pressure of the vapor space within a tank. Measured by reading the tank pressure gauge, if at equilibrium..

Entrainment

Liquid carried along with venting gas. This can occur during violent depressurization of a tank and during the top filling of a tank with the vent valve open. Large product losses will occur during this event.

Liquid Growth

As liquid warms to higher saturation pressures, the volume increases. Warm liquid is less dense. Less dense liquid takes up more volume. Liquid growth is a safety concern if the liquid is allowed to grow until it fills the storage vessel. This condition is called liquid full or hydraulically full. During this condition the pressure rises rapidly, the safeties will relieve, and the tank will vent liquid.

Pressure Drop

Pressure lost due to the flow of liquid. The faster liquid flows through the piping circuit, the higher the pressure drop.

Stratification

Warm liquid is less dense. This less dense liquid will find its way to the top of the tank. Colder more dense liquid will remain at the bottom. The layering of temperature zones from top to bottom is called stratification.

Operations

Setup and Preparation of Equipment for Use

This trailer was shipped from Chart Inc. cleaned, tested, purged with nitrogen, and, in the case of some units, filled with and in hydrogen service. All lubrication points were fully serviced.

1. Upon receipt at the site, the trailer should be examined for broken or damaged lights, gauges, tubing, pneumatic and electric conduit, piping, cracked joints, and valves. Look particularly for broken glass, bent pointers and bent valve stems.
2. Inspect all equipment for the presence of grease, oil, or organic matter that might come in contact with liquid or gaseous hydrogen. Remove any such foreign matter completely.
3. Check vacuum to be sure that it has not been lost during shipment.

Operating Instructions

See Piping Schematic in the Trailer Dossier.

Before operating the trailer, become familiar with the safety precautions described in Section 1.1 of this manual. Study the figures, particularly the P&ID and the rear compartment piping diagrams which are included in the appendices. Also study the descriptions of the equipment contained in Section 1.2.

Thoroughly read and understand the instructions in this manual BEFORE operating the equipment. Direct any questions about this system to your supervisory personnel. Untrained personnel should NOT be permitted to operate any equipment.

When performing any operation on equipment that has not been purged with nitrogen gas, connect a grounding cable to the trailer chassis.

When filling the trailer with liquefied hydrogen for the first time or refilling it after it has been out of service, the trailer must be purged and precooled generally as follows:

4. Dry the inner container with warm air or nitrogen gas
5. Nitrogen gas purge
6. Liquid nitrogen precool/purge
7. Cooldown

8. Purge/leak check
9. Evacuation or sweep purge with cold hydrogen gas
10. Pressure purge

The detailed procedures for purging and precooling are contained in this chapter, as well as the procedures for loading and unloading the trailer. Other operating procedures are contained in subsequent sections of this manual.

When discharging hydrogen or nitrogen gas to the atmosphere, observe the safety precautions for handling liquefied hydrogen and nitrogen.



Caution! *If a warm tank is filled before pre-cooling structural damage may result.*

Cooldown and Purge

11. Position the tractor and trailer so the transfer hoses can reach the connections without sharp bends. Set the brakes and place the wheel chocks in position.
12. Connect the grounding cable to the trailer chassis.
13. Close all trailer valves and cap all connections (refer to the labeled photograph of the rear compartment, Trailer Dossier) except liquid phase (fill and withdrawal) and gas phase hose connections.
14. Remove protective cap from transfer hose. Connect transfer hose cold nitrogen gas source to the gas phase connection (C2). In order to connect transfer hose to the gas phase connection (C2), the anti-towaway flag system will have to be lowered. This will lock the brakes.
15. Open valve (HV11) and admit cold nitrogen gas to inner container.
16. Apply tractor air pressure to the green gladhand or auxiliary air pressure through customer air connection (CP1) and set the four remote emergency shutoff valves (HV105A,B,C,D) to the "open" position to open valves (UV9) and (UV10).
17. Open valve (HV9) and discharge nitrogen gas through the liquid phase connection (C1).
18. Continue gas flow until the exiting gas temperature is below -200° F. Close valve (HV9).

19. Close valve (HV11), open valve (HV71), disconnect transfer hose and replace protective cap on gas transfer hose.
20. Remove protective cap from liquid transfer hose and connect the hose from a liquid nitrogen source to the liquid phase connection (C1).



Caution! *If your trailer is equipped with HQK fittings, do NOT use tools on the handwheel of the “V” band clamp. These fittings should be HAND TIGHTENED ONLY.*

21. Open valve (HV9M) and slowly charge the container with 100,000 cubic feet (NTP) of liquid nitrogen (approximately 931 gallons). Make sure container pressure does not exceed 20 psig during cooldown.



Warning: *Trailer must not be moved containing any amount of liquid nitrogen due to risk of damage to load rods and baffle.*



Caution! *The liquid level gauge and liquid level chart are intended for liquid hydrogen and will not be a reliable method for determining the amount of liquid nitrogen inside the trailer.*

22. Close valve (HV71), open valve (HV11) to discharge nitrogen gas through the gas phase connection. Open valves (HV22A) and (HV7B) to rear pressure gauge. Maintain inner container pressure at 25 psig for purging.
23. Close valves (HV9) and (HV11). Open valve (HV12). Crack open valve (HV88) one quarter turn and valve (HV71) for 30 seconds, then close. Throttle or close valve (HV12) and/or throttle valve (HV11) to maintain container pressure at 25 psig.
24. Close valves (HV21B) and (HV22B), then disconnect the two tubing fittings at the liquid level gauge (LI19). Open valves (HV21A) and (HV21B) and discharge nitrogen gas through the fitting for ten seconds. Close valve (HV21B) and reconnect the fitting. Repeat this procedure for valve (HV22B).
25. Loosen the fitting at each pressure gauge (PI20A/PI20B). Open valves (HV10), (HV21B), (HV23) and (HV7B) (at rear gauge) and purge for 10 seconds. Close valve (HV7B). Open valves (HV22B) and (HV7A) and purge for 30 seconds. Close valve (HV7A). Reconnect tubing fittings.
26. Open valves (HV34) and (HV35) and purge for 10 seconds. Close valves (HV34) and (HV35).
27. Open valves (HV10), (HV21B), (HV22B), (HV23), (HV7A) and (HV7B).
28. Open valve (HV91), disconnect transfer hose from liquid phase connection (C1). Replace protective caps on hose and pressure caps on the liquid and gas phase hose connection.
29. The trailer may be left unattended during the cooldown by opening valve (HV14A). Road relief valve (PCV15) will relieve container pressure when it exceeds 17 psig.
30. During cooldown, reduce container pressure to 1 psig by opening blowdown valve (HV12).



Note: *For maximum cooldown, keep liquid nitrogen in the trailer for 72 to 96 hours. A shorter nitrogen cooldown will produce higher hydrogen cooldown losses*

31. Close all valves except (HV21A), (HV22A), (HV21B), (HV22B), (HV7A), and (HV7B).
32. Open valve (HV42). Apply tractor air pressure or auxiliary air pressure through customer air connection (CP1) and set the four remote emergency shutoff valves to the “open” position to open valves (UV9) and (UV10).
33. Throttle valve (HV10) to maintain container pressure between 5 psig (minimum) and 100 psig (maximum).
34. Open valve (HV76) and remove pressure cap from the gas phase connection. Open valve (HV11) and discharge gas for 10 seconds. Close valve (HV11) and replace cap immediately. Open valve (HV11) and discharge nitrogen gas through valve (HV76) for 10 seconds. Close valves (HV76) and (HV11).
35. Remove cap from sample valve (HV34) connection (C30), open valve (HV34) and purge for 10 seconds. Close valve (HV34). Replace cap (C30).
36. Remove pressure cap from the liquid phase connection. Open valve (HV9) and discharge nitrogen gas for 10 seconds. Close valve (HV9) and replace cap immediately. Open valve (HV9) and (HV71). Purge for 10 seconds, then close valve (HV71).
37. Open (HV70A or HV70B) from isolated outlet of valve (HV59). Switch valve (HV59) and purge for 10 seconds. Switch valve (HV59) back and close (HV70A or HV70B). Switch valve (HV59) again and repeat the procedure on the other side after opening (HV70A or HV70B).
38. Using the pressure building coil, increase container pressure to 140 psig. Open valves (HV9), (HV42), (HV11), (HV21A), (HV21B) and (HV7A/7B). Exercise valve (HV59) at least three times during the leak check.

39. Check all connections, joints, safety devices, valves and gauges for leakage. Check both outlet circuits of valve (HV59). Repair all leaks immediately.
40. When cooldown, purging and leak testing of the external piping are completed, drain the residual liquid nitrogen from the container. Allow the trailer to remain in a closed condition for 2 hours, then proceed.

Sweep and Pressure Purge

41. Complete the cooldown, purge and leak test procedure per Section 2.2.1. Trailer and vent stack grounding cables must be connected. Open valves (UV9) and (UV10). Valves HV105A, HV105B, HV105C, and HV105D must be in the “open” position and a minimum of 30 psig air pressure is required.
42. Open valve (HV76) to bleed off pressure. Remove protective caps from the gas phase connection (C2) and the vent line hose. Connect the hose. Close valve (HV76).
43. Open valve (HV71) to bleed off pressure. Remove protective caps from the liquid phase connection (C1) and the liquid transfer hose. Connect the hose from a hydrogen gas source. Close valve (HV71).
44. Open the hydrogen gas supply valve. Open valve (HV71) and purge the transfer hose for ten seconds. Close valve (HV71).
45. Open valve (HV9) and admit gaseous hydrogen to the container. Open valve (HV11) and release purge gas to the vent stack.
46. Obtain gas samples by opening valve (HV34). Continue sweep purge until a gas analyzer indicates a nitrogen in hydrogen concentration of less than 1% by volume.
47. Open valves (HV10) and (HV42). Continue sweep purge until the nitrogen in hydrogen concentration is less than 1% by volume. Close valve (HV10).
48. A pressure purge cycle consists of the following steps. Close valve (HV11) and increase container pressure to 15 psig. Allow container to remain at 15 psig for 30 minutes. Open valve (HV11) and blow down container to 1 psig. Close valve (HV11).
49. Perform pressure purge cycles until nitrogen in hydrogen concentration is less than 0.1% by volume. Obtain gas samples through valve (HV34). At least three or four pressure purge cycles are typically required to obtain this concentration level. After final pressure purge, leave a residual pressure of at least 5 psig in the container.

50. Purge external piping and valves with hydrogen gas per steps 14, 15, 16, 17, 24 and 26 of Cooldown and Purging.
51. Pressure purge the container three additional times if hydrogen with a maximum impurity of 5 parts per million by volume is required. For impurity of 25 parts per million by volume, one additional pressure purge is required. No additional pressure purges are required for impurity of 50 parts per million by volume.
52. If impurity is based on parts per million by weight, perform four pressure purges in addition to those indicated in Step 11.
53. Close cold hydrogen gas supply valve. Close all valves except valves (HV21B), (HV22B), (HV7A) and (HV7B).
54. Disconnect transfer hose from the liquid phase connection. Replace protective cap on the connection immediately. Replace protective cap on the transfer hose. Open valve (HV14A).
55. Disconnect vent line hose from the gas phase connection. Replace cap on the connection immediately. Replace protective cap on the vent line hose.
56. Disconnect trailer ground cable. Remove wheel chocks and move trailer to hydrogen fill area.

Normal Trailer Fill

57. Check name of product at source to ensure hydrogen is product being loaded into trailer. Position trailer, shut-off tractor, set brakes, and position wheel chocks.
58. Connect ground cable. Close all valves except (HV21B), (HV22B), (HV7A) and (HV7B), and then open bleed valves (HV71) and (HV76). Remove protective caps and connect transfer hoses to liquid connection (C1) and the gas phase connection (C2). Check purity by connecting sample hose to valve (HV34) fitting and analyzing. Purge hoses and lines while liquid supply valve is cracked open slightly.



Note: You **MUST** recover the trailer flash-off through the transfer hose connected to the gas phase connection.

59. Blow down vessel to 2 psig. Open valve (HV11). Open air operated valves (UV9) and (UV10). Valves HV105A, HV105C, and HV105D must be in the “open” position and a minimum of 30 psig air pressure is required.
60. Begin filling vessel by opening supply valve and liquid fill valve (HV9).



Caution! OPEN VALVES SLOWLY AND WITH EXTREME CARE. BE SURE ALL CONNECTIONS ARE TIGHTENED SECURELY TO AVOID LEAKS DURING LIQUID TRANSFER.

61. Open supply valve and liquid fill valve (HV9) fully, and throttle gas phase withdrawal valve (HV11) to control vessel pressure in the range of 1 or 2 psig.

Filling by Weight

If filling by weight

1. Load the trailer with 10,160 lbs. of hydrogen at 2 psig saturated pressure (or equivalent at alternative saturated filling conditions.
 - a. The true weight of liquefied hydrogen in the trailer is the difference between the full and empty weight, added to the weight of the gas displaced by the liquefied hydrogen during filling. Under the above initial and final weighing conditions of 2 psig, the weight of the gas displaced is 2.19% of the differential weight, assuming that the displaced gas and the added liquid are at saturated conditions of 2 psig.

EXAMPLE

- Differential weight before and after filling — 9942 lbs
- Weight of displaced gas = 2.19% x 9942 lbs — 218 lbs
- Total weight of liquefied hydrogen in trailer = 9942 + 218 lbs — 10160 lbs

For filling pressures where saturation is maintained, the weight of the displaced gas is as follows:

Pressure (PSIG)	Weight of Displaced Gas (% of Differential Weight)
0	1.93
2	2.19
4	2.44
18	4.35

For other filling conditions where the initial and final pressures are different or the displaced gas is not at saturation, the weight of the displaced gas can be calculated as follows:

$$W=(PG/PE)/(1-PG/PE)$$

- W = Weight of the displaced gas expressed as a percentage of the differential weight

- PG = Density of gas in the trailer at time of initial weighing
- PE = Density of liquid in trailer at time of final weighing

2. Once the total full weight has been established for each trailer, do not exceed this weight.
3. Blow down container through vent line valve to 2 psig. Open supply valve and top off container to replace product lost by evaporation during blowdown.

Customer Fill

This item describes how to safely transfer liquid hydrogen from a trailer to a customer’s tank. Throughout this procedure, valves and connections are numbered according to the standard numbering system used on hydrogen trailers. These are recommended procedures for proper operation. Always follow your company approved procedures for unloading as well.

This trailer is equipped with air-operated emergency valves labeled (UV9) and (UV10) as well as manually- operated valves that are labeled (HV9) and (HV10).

Before leaving the Hydrogen Plant:

1. Perform pre-trip vehicle inspection
2. Prepare DOT required paperwork
3. Check the trailer’s road relief valve (HV14A). This valve must be completely open for the 17-psig road relief system to operate properly.
4. Ensure the pneumatic PB safety valve system is activated by opening (HV32). This system should be activated at all times.
5. Obtain the necessary personal safety equipment for handling hydrogen (safety glasses, face shield, hard hat, gauntlet glove, and flame-retardant suit)



Warning: Failure to wear protective clothing and equipment while handling cryogenic products may result in serious personal injury.

6. If the trailer’s pressure is too high to permit delivery within the prescribed one-way travel time, reduce pressure by sloshing liquid or venting. If the pressure does not reduce to an acceptable level, contact your supervisor.
7. Follow prescribed route to the customer

Upon arrival at the customer site:

1. Obey all customer site regulations such as yard speed limits.
2. Properly position the vehicle so that the transfer hose will easily reach the connection on the customer's tank. A transfer hose that is crimped or under tension may leak or create other unsafe conditions during the transfer.



Note: Extreme caution should be used when backing up a vehicle. It may be necessary for the driver to stop the vehicle and inspect the area behind the vehicle a number of times during the backing-up operation. If someone is directing the driver, both driver and director must have a clear understanding of the hand signals being used. However, the use of a director does not relieve a driver of responsibility for any damage caused by the vehicle while it is backing up.

3. Put on personal safety equipment (safety glasses, face shield, hard hat, gauntlet gloves and flame-retardant suit).
4. Set the air brakes, shut off the tractor engine, and remove the ignition key.
5. Remove the glad hand from the supply line (RED) and place on the auxiliary glad hand (GREEN) to supply the emergency valves with air.



Warning! Failure to wear protective clothing and equipment while handling cryogenic products may result in serious personal injury.

6. Properly ground the trailer before continuing with this procedure by attaching the customer's ground cable to the trailer.
7. Check the trailer's pressure gauge reading and the working pressure indicated on the trailer. Be sure the trailer's pressure does not exceed its working pressure during the unloading procedure.
 - a. Operating parameters of Liquid Hydrogen Trailer
 - b. Working Pressure: 155psi
 - c. Max Operating pressure for unloading: 135psi or customer policy

8. If the customer's tank pressure is greater than 125 psig, contact your supervisor for further instructions before continuing with this procedure. Activate the trailer's anti-tow interlock device by lowering the bayonet lever flags. Connect transfer hose to withdrawal bayonet (C3).
9. Deactivate the trailer's road relief system and activate the 155 psig system by closing (HV14A), (HV14B), and opening (HV14C).
10. Check to ensure that the trailer's manually-operated liquid fill and withdrawal valve (HV9) is tightly closed. To open the air operated valves at customer tank (if equipped) connect an airline from customer tank to (CPI).
11. Open the trailer's liquid phase fill and withdrawal drain/purge valve (HV71) for unmetred withdrawals or the trailer's metered withdrawal drain/purge valve (HV72) for metered withdrawals.
12. Check to make sure that the customer's tank liquid and gas fill valves are closed.
13. Open the customer's fill line purge valve. A small amount of gas may vent from the purge valve out through the vent stack. If gas continues to vent for more than a few seconds, close the purge valve and follow troubleshooting instructions.
14. 16. If the customer's purge valve stops venting, remove the protective caps from the trailer and tank connections. Be sure the trailer's liquid-phase drain/purge valves (HV71) or (HV72) and the customer's fill line purge valve are open before removing the protective caps.
15. Inspect the connections for dirt and foreign material and wipe them with a clean cloth. Inspect the "O" rings for damage and replace them, if necessary.
16. Remove the transfer hose from the storage tube on the trailer. Do not contaminate the hose by dragging the connections on the ground. Be careful of sharp burrs that may have developed on the hose connections. Check the tank connection against the hose connection to be sure they match. If the connections do not match, contact the appropriate personnel; do NOT continue with this procedure.
17. Inspect the hose end connections for damage. Wipe off any foreign material with a clean cloth and install a new gasket. Connect the transfer hose to appropriate trailer connection.



Note: For unmetred withdrawals, connect the hose to the trailer's liquid-phase fill/withdrawal fitting at (C1). For metered withdrawals, connect the hose to the trailer's liquid-phase metered withdrawal fitting (C3).

18. Remove the protective cap from the other end of the hose and inspect the nozzle piece for damage and foreign material. Wipe the nozzle piece with a clean cloth and insert it into the customer's tank fill connection so the vacuum plug is pointing toward the ground. Tighten the clamp so that the "T" bolt is either parallel or perpendicular to the customer pad.



Caution! Do not use tools to tighten the hand wheel on the "T" bolt clamp. Hand tight only.

19. Check the trailer's gas-phase return valve (HV11) to be sure that it is closed. Open Gas Phase Bleed Valve (HV76). Uncap the gas-phase connection and attach one end of the gas blowdown hose. Connect the other end of the hose to the customer's tank vent stack and, if present, open the vent stack valve.
20. Purge the transfer hose by partially closing the trailer's liquid-phase drain/purge valves (HV9M) or (HV88) leading to the connected hose. Purge the hose for 2 minutes through the customer fill line purge valve.
21. Close the customer's fill line purge valve, and then the trailer's manually-operated liquid supply valve (HV9) or (HV88), leaving the hose pressurized. Check all hose connections for leaks.
22. If any leaks are found at this time or any time during the transfer, close the liquid and gas fill valves on the customer's tank, and close the trailer manual liquid supply valves (HV9) or (HV88). Relieve all pressure in the hose by carefully opening the purge valves on the trailer (HV91) or (HV72) and on the customer's tank. Correct leaks as follows:
- Hand tighten the "T" bolt clamp.
 - Disassemble the connection, inspect the Kel-F "O" rings for damage and replace them, if necessary.
 - Inspect and replace the hose seal, if necessary.
23. After correcting leaks, return to step 20 and restart the purge procedure.
24. After achieving a successful leak test, vent the transfer hose through the customer's fill line purge valve and then close the purge valve. Re-pressurize the transfer hose by slowly opening the trailer's manually-operated liquid supply valve (HV9) or (HV88) and closing it again. Wait 30 seconds, and then reopen the customer's fill line purge valve long enough to relieve the pressure on the hose. Close the purge valve after pressure is relieved.
25. Repeat step 24 five (5) times, or until the tank purge valve line begins to frost. Close the customer tank fill line purge valve after the last hose venting.

26. Open the trailer's pressure building coil return valve (HV42).
27. Open the trailer's manually-operated liquid-phase pressure building coil valve (HV10), and build the trailer's pressure 10 to 15 psig above the customer's tank pressure. Do not use the customer's tank to pressurize the trailer.



Warning: Do not exceed the trailer's Maximum Allowable Working Pressure (MAWP), which is marked on the trailer.

28. For unmetered delivery, proceed as follows.
- Open the trailer's manually-operated liquid fill and withdrawal valve (HV9), and the customer's tank gas phase fill valve.
 - Go to step 33 and proceed with offloading procedure.
29. For metered delivery, proceed as follows:
- Open meter withdrawal valve (HV88) 1 or 2 turns, and open meter purge valve (HV72). After approximately 2 minutes, when the meter purge lines begin to frost, open purge valve (HV91) and the customer's fill line purge line. Leave valves open until the meter's out-of-range light goes out. Close valve (HV72) and (HV91) and customer's fill line purge valve when meter cooldown is completed. Record totalizer reading on meter.
 - Slowly open the meter withdrawal valve (HV88) on the trailer and the customer's gas fill valve.
30. The customer's tank is set to operate at a designed minimum pressure. Maintain the tank's pressure between its minimum pressure and its MAWP by opening or closing the customer's tank liquid or gas fill valves. To lower the tank's pressure, open the gas valve and throttle the liquid valve; to raise it, open the liquid valve and throttle the gas valve.
31. To unload all product from the trailer, maintain the pressure in the trailer 10 to 15 psig greater than the customer's tank pressure. However, do not let the trailer's pressure exceed its MAWP or the safety valve settings on the customer's tank. Maintain the trailer's pressure until either the customer's tank is full or the trailer is empty.



Caution: Remain at the back of the trailer during the entire unloading procedure to take corrective measures promptly.

32. When the customer's tank liquid contents gauge approaches the full mark, open the customer's tank full trycock valve and watch the customer's fill termination device (gauge).
33. When the gauge needle begins to fluctuate, or the customer's tank pressure begins to rise rapidly, close the customer's tank liquid fill valve and full trycock valve. Close the trailer liquid supply valve (HV9) or (HV88).
34. Close the trailer's manually operated liquid phase pressure building coil valve (HV10). Turn off the metering system and take a reading.
35. Disconnect the gas blowdown hose from the trailer and vent stack, and securely cap the trailer and hose connections.
36. Complete the required paperwork.
37. Close the trailer's gas phase pressure building coil valve (HV42).
38. Close air-operated valves (UV9) and (UV10) by operating the emergency shut-off valve (HV105D) at rear of trailer.
39. After all liquid product in the transfer hose has vaporized, close the customer's tank gas phase fill valve.
40. Open the customer's fill line purge valve and the trailer's purge valve (HV71) for trailers without meters, or (HV72) for trailers with meters, to vent pressure from the transfer hose to the vent stack.
41. When the transfer hose stops venting, disconnect the transfer hose from the trailer, pointing the end of the hose down and away from you as you disengage the hose from the connection. Close the purge valves on the customer's tank and trailer (HV71) or (HV72).
42. Disconnect the transfer hose from the customer's tank, and cap and store the transfer hose in the trailer's storage tube. Securely cap the customer's tank liquid connection.
43. Securely cap the trailer's liquid connection.
44. Leak test the liquid connection cap and remove air from the liquid line by opening and closing the trailer's vapor purge (HV90) or (HV91); vent through drain purge valve (HV71) or (HV72). Remember to leave only a slight positive pressure on this end connection. Close valve (HV71) or (HV72). Check the connection cap for leaks; do not attempt to repair leaks while the cap is under pressure. Check all other valves to be sure they are tightly closed.
45. Leak test the customer's tank fill connection cap in the same manner as above to remove any air from the fill line by slightly opening and closing the gas fill valve and venting through the tank's purge valve. Close the purge valve, leaving a slight positive pressure on the end connection. Check the connection cap for leaks; however, do not attempt to repair leaks while the cap is under pressure.
46. Check all other tank valves that were opened during this procedure to be sure that they are tightly closed.
47. Deactivate the trailer's anti-tow interlock device by raising the bayonet lever flags.
48. Remove the ground wire clamp from the trailer.
49. Recheck the customer's tank liquid and gas fill valves to be sure they are tightly closed.
50. Walk around the vehicle, and visually inspect to ensure that it is safe to move.
51. Remove and store the wheel chocks and ensure cabinet doors are closed and latched.
52. Reduce the pressure in the trailer by driving the trailer and bringing it to a sudden stop. Repeat if necessary.
53. Check the readings on the trailer's contents gauge (LI19) and pressure gauge (PI20A). Determine the travel time to the next customer or the plant. Determine the proper road relief isolation valve settings, and whether the trailer should be blown down before leaving the customer's site.
54. If blowdown is required, follow prescribed personnel safety procedures and blowdown procedures.

Abnormal Situations

Excessive Pressure Rise

1. Empty Trailer -If pressure rise exceeds 1 psig for every 2 hours of travel time when the trailer is empty, follow the troubleshooting instructions. This situation is critical when the time to the next destination is greater than the time it will take for the pressure to rise above the DOT legal limit for travel (varies based on density; 150 psi max at 4.5% density).
2. Full or Partially Full Trailer - If the pressure rise exceeds 0.2 psig for every 2 hours of travel time, follow troubleshooting instructions.

Reading Tank Pressure

1. Reading the rear pressure gauge (PI20B)
 - a. Open the needle valve (HV7B) on the instrument panel and read tank pressure directly in PSIG from gauge on the panel.

2. Reading the front pressure gauge (PI20A)
 - a. Open the needle valve (HV7A) on the instrument panel and read tank pressure directly in PSIG from gauge on the front gauge panel.

Reading Liquid Level

To read the level of the liquid, in inches of water, proceed as follows:

1. Check “ZERO” setting of the gauge by closing the needle valves in the panel marked (HV21B) and (HV22B) and opening the valve marked (HV23). Gauge needle should read zero.
2. Close (HV23) and open (HV21B) and (HV22B). Read inches of water directly from gauge on the panel.
3. A conversion chart in inches of water to gallons of liquid hydrogen is mounted on the curb side compartment door. A copy can also be found in the Trailer Dossier. This provides approximate liquid level.

Reading Vacuum

A Teledyne Hastings Thermocouple tube (DV-6R) has been furnished with this trailer.

1. Carefully plug gauge to tube (52A).
2. Be sure that vacuum gauge tube shut-off valve (HV52) is open. Wait 15 minutes for stabilized reading.
3. Read vacuum in microns.
4. Close vacuum gauge valve (HV52) before removing gauge connection (52A).

Taking a Liquid Sample

To take a liquid sample, proceed as follows:

1. Connect sampling line to sample connection (C30).
2. Open sample valve (HV34).
3. When sampling is complete, close (HV34).

Lifting Trailer Empty

Four (4) lifting lugs have been provided with this vehicle. By using cable and shackles the trailer may be lifted or righted by one crane or two, depending on availability. It is recommended that all product be removed prior to lifting.

Moveable Kingpin Plate

This vehicle is equipped with an 9-position movable kingpin Plate.

1. The trailer was assembled and delivered with the plate in the #7 position for optimum weight distribution with the indicated tractor.
2. Each position is 3” apart.
3. To increase trailer tandem weight, move the plate forward.
4. To decrease trailer tandem weight, move the plate to rear.
5. Make sure all bolts are in place and tight.
6. Recommended torque - 200 +/- 10 FT LBS

Safety Relief Valve Removal

To remove a container safety relief valve under pressure, proceed as follows:

1. Move the handle of the diverter valve (HV59), 90 degrees. Direction of flow is shown on the valve handle.
2. Remove desired part. Trailer may not be used until replacement or repaired part is re-installed.

Inner Vessel Repairs

If inner vessel repairs due to accident, loss of vacuum, or other circumstances become necessary, it is strongly suggested that the trailer be returned to Chart Industries. Should this not be practical, the following procedure — which will void all warranties — is suggested for access to the inner vessel:

1. Purge the inner vessel per procedures in this manual.
2. Break the vacuum in the annular space and purge with nitrogen gas.
3. Locate, mark and cut a 24” x 24” hole the center of which is 31 inches from the front head to shell weld and 22 inches along the circumference from the top center line of the casing, road side.
4. Remove a 22” x 18.5” section of the insulation.
5. Cut an appropriate manway.
6. When repairs are completed clean the container of particles and contaminants.
7. Seal the access hole with a backing ring and a manway cover.

8. Mass Spectrometer, and UT Test the weld.
9. Restore insulation to container at manway.
10. Seal casing access hole with lap patch.
11. Restore vacuum to annular space.
12. Mass Spectrometer Test casing.



Note: *Chart Inc. takes no responsibility for the implementation of the above described procedure. This is a very difficult operation and should be performed by experienced, qualified organizations with A.S.M.E. certifications.*



Note: *All warranties pertaining to thermal and structural performance or integrity of the container, casing, and insulation system are voided if this work is not done at a Chart facility.*

Suspension Air Bag Dump Valve

A manually operated toggle valve to quickly empty the Hendrickson suspension air bags has been provided. It is installed inside the rear compartment on the roadside valve panel. It is recommended that the air bags be emptied before disconnecting the tractor and loading or unloading product from the trailer. Before driving off, make sure the valve is in the “suspension up” position. Emptying the bags will lower the piping compartment approximately 3”.

Flowmeter Operation

For flowmeter operating instructions please refer to manufacturer’s manual in the Trailer Dossier.

Troubleshooting

Use the following troubleshooting table as a guideline to diagnose your Chart system should problems develop. This table cannot replace the knowledge that an experienced operator or cryogenic technician has, and should be considered as a guide only. The table consists of the Symptom, Probable Cause and Remedy columns. Probable causes for a specific problem are listed in a descending order of significance. That is, check out the first cause listed before proceeding to the next. The error codes reference the Flowcom® Flow Meter System Installation and Service Manual.

Symptom	Probable Cause	Remedy
Loss of vacuum or inability to produce good vacuum	Leak in safety head Leak in outer shell Leaking vacuum valve Leak in inner vessel	Replace O-ring in the safety head. Use a suitable vacuum grease such as Celvacene Find Leak. Use leak detector if available or apply vacuum grease to the welds while running the vacuum pump until vacuum improves. When leak has been located, repair, by welding or soldering. Soap test outer shell Replace valve M/S Test if possible. Contact manufacturer.
Leaking Valves	Bent stem Worn seat	Replace valve Replace valve seat
Leaking safety relief valve	Valve worn or stuck in open position	If gentle tapping does not relieve condition, replace valve. See Maintenance chapter.
Trailer tank pressure continues to build up rapidly	Leaking pressure build-up valve.	Replace valve disc and/or seat
Excessive trailer tank pressure	Safety relief valve not operating	Replace valve
Liquid level gauge does not read	Damaged gauge or plugged line Damaged iso valve	Replace gauge, repair or clean piping Replace valve
Pressure gauge does not read	Damaged gauge Damaged or plugged line Damaged iso valve	Replace gauge Repair or clean out piping Replace valve
Vacuum gauge does not read	Battery is weak Thermocouple tube damaged Control box damaged	Replace battery Replace tube Replace control box
Brakes running hot	Improper adjustment	Adjust brakes properly

Symptom	Possible Cause	Remedy
No brakes (spring brakes excepted)	<p>Source of air supply shut off at towing vehicle</p> <p>Low brake line pressure on towing vehicle</p> <p>Brake lines between towing vehicle and trailer not properly coupled</p> <p>Air tank drain cock open or moisture trap open</p> <p>Leaky or broken connection</p>	<p>Open shut-off cocks at rear of towing vehicle</p> <p>Check air pressure gauge</p> <p>Properly couple brake lines</p> <p>Close drain cock or moisture trap</p> <p>Replace or repair</p>
Uneven braking	<p>Brake out of adjustment</p> <p>Damaged brake chamber or internal brake assembly</p>	<p>Adjust brakes</p> <p>Repair or replace affected parts</p>
Wobbly wheels	<p>Loose wheel studs</p> <p>Inner/outer wheel bearings worn or damaged</p> <p>Bent axle</p>	<p>Tighten studs</p> <p>Replace worn/defective bearings</p> <p>Repair or replace</p>
Broken or missing hanger bolts	Loose bolts	<p>Inspect and tighten per maintenance schedule.</p> <p>Replace with high strength SAE fastener</p>
Uneven tire wear	<p>Over or under inflation</p> <p>Duals not properly matched</p> <p>Improper wheel bearing adjustment</p> <p>Axle bent or out of alignment</p>	<p>Inspect all tires and inflate to proper pressure</p> <p>Match duals</p> <p>Inspect/adjust bearings properly</p> <p>Replace, repair or align. See vendor literature in the Trailer Dossier.</p>
Landing leg support crank difficult to turn	<p>Lack of lubrication or improper lubricant used</p> <p>Bent crank operating shaft</p> <p>Gears damaged or stripped</p> <p>Bent operating shaft</p>	<p>Lubricate properly with manufacturer's recommended lubricant. See vendor literature in the Trailer Dossier.</p> <p>Repair or replace</p> <p>Replace</p> <p>Repair or replace</p>
Frost spots or sweating on tank	<p>Torn or damaged insulation</p> <p>Loss of vacuum</p>	<p>Call manufacturer</p> <p>Leak check. Repair. Re-evacuate</p>

Suggested Preventative Maintenance Schedule

Item	Operation	Performance Interval
Suspension and running gear	Torque all nuts, bolts and air-line fittings on air suspension and check air suspension	Every 3,000 miles
	Steam clean body, kingpin area and chassis	Every 7,500 miles
	Complete lubrication	Every 7,500 miles
	Check air bags	Every 7,500 miles
	Check sub-frame for cracks and looseness	Every 7,500 miles
	Check landing gear operation	Every 7,500 miles
	Drain air tanks - check for moisture	Every 7,500 miles
	Check air lines for rubbing or cracking	Every 7,500 miles
	Inspect kingpin for wear and looseness	Every 7,500 miles
	Dye check fifth wheel plate for cracks	Every 6 months
	Drop and inspect bolt on fifth wheel plate	Every 24 months
	Check torque on wheel nuts	Every 7,500 miles
	Inspect linings and drums	Every 60,000 miles
Check wheel bearings (repack if needed)	Every 60,000 miles	
Tires	Check for bruises, cuts, and tread depth	Every 7,500 miles
	Check dual mating	Every 7,500 miles
	Inflate to prescribed pressure	Every 7,500 miles
Misc. Components	Inspect body, fenders, compartment doors	Every 7,500 miles
	Check all lights, reflectors, and wiring	Every 7,500 miles
	Check all air lines and coupling for leaks	Every 7,500 miles
Cryogenic Equipment	Inspect all hand valves for leaks	Daily
	Check valve packing nuts	Monthly
	Inspect safety relief valves for leaks	Daily
	Test all safety relief valves	Every 12 months
	Replace rupture burst discs	Every 12 months
	Check fusible links	Monthly
	Inspect transfer hose and couplings	Monthly
	Replace O-ring on connections	As Needed
	Check zero "0" readings on contents gauge	Daily
	Check vent drain	Daily
	Check air operator valves for smooth operation	Monthly
	DOT Visual Inspection	Every 12 months
DOT Pneumatic Test	Every 60 months	

Maintenance & Repair

Inspection

General

This section contains maintenance information. Most parts to aid in service and repairs are easily accessible and replaceable. Before performing any of the procedures in this section be sure you are familiar with the location and function of controls and indicators discussed in other sections. It is recommended that the Safety section of this manual be reviewed and understood fully.

Maintenance required usually becomes apparent during inspection of units before a fill routine, observations during and after a fill, and from improper performance of components. Proper and immediate action to correct any damage or malfunction is advised.

Persons making repairs to piping, valves, and gauges must be familiar with cleanliness requirements for components used in nitrogen, oxygen, argon or carbon dioxide service.

Running Gear

A thorough inspection of the wheels, tires, axles, brakes, air springs and shocks should be made after the first 500 miles.

Daily inspection of the tires and bolts should be made.

Normal periodic inspection of all other automotive parts should be conducted for wear and damage.

Pneumatic and Electrical System

The pneumatic and electrical systems should be periodically checked for damaged tubing and conduit, leaks, worn or frayed insulation and burned out bulbs.

The air reservoirs should be drained of moisture.

Fastenings

All pipe supports, and all nuts and bolts should be checked once a week for missing parts and tightness.

Lubrication

Running Gear

Check the oil level periodically and add SAE 80W-90 synthetic gear oil as needed.

Landing Gear

Lubricate the landing gear with wheel bearing type grease as needed.

Vacuum

Vacuum should be checked if trailer is experiencing excessive pressure rise or abnormal product loss.

The gauge should read 10 microns of mercury or less when the tank is cold, 50 microns when the tank is warm. If it reads more than this re-evacuation is desirable. To re-evacuate the tank, the following procedure should be used.

1. Allow the inner shell to warm up to room temperature. If there is liquid in the trailer, re- evacuation may be performed but the results will be less effective. A faster evacuation can be achieved by heating the inner vessel with hot oil free dry air or nitrogen at 130° F.
2. Evacuate the tank as follows:
 - a. Connect a vacuum pump to the tank vacuum connection. Be sure that a sump or “fail- safe” solenoid is in the line to protect the tank against a power failure of the pump, resulting in oil saturation of the insulation.
 - b. Evacuate the line between the pump and the tank shut off valve, and then slowly open the tank valve so as not to stall the vacuum pump.



Note: *If the vacuum should ever need to be broken, always introduce dry nitrogen into the void. Never break a vacuum to atmosphere, especially if the inner vessel is cold. When breaking a vacuum, open the vacuum valve very slowly to avoid damage to the insulation.*

Soap Testing the Outer Shell

In the event of a vacuum loss in the annular space it is often desirable to soap test the outer shell or casing before or in lieu of vacuum testing with halogen or a mass spectrometer.

The following procedure should be used with Chart trailers.

1. Seal off container safety relief valve and rupture disc (if equipped) from the container by either physically removing them or placing a blind flange between the container and the vent manifold.
2. Make sure all lines and valves in direct contact with the container are leak tight.
3. Clamp the casing relief device cover with 3 “C” clamps equally spaced around the cover, to the cover flange.
4. Pressurize the inner container to 30 PSIG with dry oil free nitrogen.
5. Open the casing vacuum valve. If there is no steady outflow of gas, then the container does not have a massive leak.
6. Connect a suitable manifold with valve and gauge to the casing vacuum valve.
7. Pressurize the annular space slowly to 20 PSIG MAXIMUM.



Caution: *Surveillance of the container and annular space pressure gauges is essential. A differential of 10 PSIG should be maintained for a comfortable safety margin. One (1) PSIG external pressure on the container will cause a collapse.*

8. Soap test welds, gouges, mechanical joints and other suspect areas with “Leak Tec” or other suitable soaps.
9. When testing is complete, FIRST release pressure from the annular space.
10. When annular space is completely empty of pressure, release container pressure.
11. Reassemble container piping.
12. Remove clamps from casing relief device

Valves and Safety Devices

Shut Off Valves

Valves do not require regular maintenance. A periodic inspection for leaks is desirable.

For troubles originating from leaking valve seats, check/replace valve seats and/or discs. For bent valve stems, it is advisable to replace the valve

Safety Relief Valves

A characteristic of a high-pressure safety relief valve is its tendency to leak after it has relieved an excessive pressure condition. NEVER attempt to rectify this condition by tightening the nut on top of the safety valve and thus increasing the spring tension. If a gentle tapping of the valve does not relieve this condition, replace the valve. These valves are precision pieces of equipment and all field maintenance should be limited to replacing a faulty valve.

Insulation

This trailer has been insulated with a multilayer material. It consists of alternate layers of a fiberglass paper and aluminum foil. This material should never require any routine maintenance or service. In the event of a sudden increase in container pressure with a vacuum in the annular space of 100 microns or less, or frost or sweating of the outer vessel, there may be a problem with the insulation.

Should any of these symptoms appear repeatedly, call our office for consultation and advice.

Gauges

Pressure Gauges

Little maintenance is necessary other than replacing broken glass protecting the face and gauge mechanism from dirt. If the pointer becomes badly bent or the gauge does not read properly, it should be replaced.

Liquid Level Gauge

Little maintenance is necessary other than replacing broken glass protecting the face and gauge mechanism from dirt. If the pointer becomes badly bent or the gauge does not

read properly, it should be replaced. The “0” reading of the gauge should be checked before each use, if it is found out of adjustment it should be corrected following the manufacturer’s recommended procedure in the owner manual found in the Trailer Dossier.

Vacuum Gauge (not supplied with unit)

The first source of trouble with this gauge will be due to the battery operating the electrical circuit becoming weak with age. If the needle cannot be brought to a “stable” reading in Step 2, the battery is weak and should be replaced.

If the vacuum gauge does not give a reading, the thermocouple tube should be disconnected from the control box. The tube circuits should then be tested for continuity with an electrical continuity meter. If these circuits are intact, the control box needs repair and should be replaced.

If either of the two circuits is broken, the thermocouple tube should be replaced in the following manner.

1. Before removing the thermocouple tube, close the vacuum gauge tube shut off valve.
2. Remove the thermocouple tube and replace.

Electrical System

12-Volt Trailer System

An electrical wiring diagram is enclosed in Trailer Dossier for evaluating circuits. Be sure that bulbs and/or LED lights and other components are replaced with 12V counterparts.

Flow Meter

For flowmeter maintenance/service instructions please refer to manufacturer’s manual in the Trailer Dossier.

Emergency Shutoff and Hose Interlock/ Anti-Tow Pneumatic System

This trailer is equipped with 4 emergency stop switches (HV105A, HV105B, HV105C & HV105D) which when toggled, close the pneumatic liquid valves at rear of trailer.

This trailer is also equipped with an anti-tow-away bayonet flag system. When the bayonet flag is lowered (indicating a hose may be connected), the brakes will lock. A schematic is enclosed in Trailer Dossier for checking out flow directions and troubleshooting of the pneumatic control and emergency system.

Specifications

Model	STH-18600SS-155
Product	Liquid Hydrogen
Weight	
Empty / Full	45,900 lbs / 56,000 lbs
Dimensions	
Length	52'-9 1/2"
Width	8'-6 1/4"
Height (Empty)	13'-2 13/16" Front / 12'-1 7/8" Rear
General	
Warm Water Capacity	18,600 gallons
LH2 at MC338 Level	17,320 gallons - Maximum Permissible Weight of Liquid 10,160 lbs
Max Allowable Working Pressure	155 psig @ 120 F
DOT Max. Operating Pressure	170 psig
Design Temperature	-423 F to 120 F
Inner Vessel Construction	
Material	SA-240 304N Stainless Steel
X-Ray	RT-1
Design and Construction Code	ASME Section VIII Div. 1 (2019 Edition)
Manway	None
Number of Baffles	1
Diameter	97-3/4"
Outer Vessel Construction	
Front Head and Shell Material	SA-516 Gr.70 Carbon Steel
Rear Head, Above KP/Chassis	AISI 304 Stainless Steel
Design and Construction Code	DOT MC338
Insulation	SI Wrap (NER 0.7%)
Annular Space Pressure	10 Microns (warm)
Diameter	102-1/4"
Kingpin Structure	
Manufacturer	Chart Inc. (P/N 22033791)
Type	Bolted adjustable
Adjustment Forward/Rearward	27"
Loaded Height	48"
Kingpin Type	Holland Mushroom Series (KP-T809F)
Landing Gear	
Model	Holland Mark V (LGS-3A105-0000)
Distance from Kingpin (nominal)	109-7/8"
Running Gear	
Suspension	Hendrickson AAT25K ((INTRAAX.123770 Front / INTRAAX.123769 Rear))
Axle Type	5.75" Round, 77.5" Track, Air Disc Brakes
Anti-Lock Brake System	Wabco (4801070010)
Hubodometers	Stemco# 650-0613
Tire Inflation System	Hendrickson TIREMAAX.7142
Tires	Michelin XTE 275/80 R22.5 P/N 24179
Wheels	Alcoa Aluminum #883677

Chassis	Chart Inc. Stainless Steel (P/N 22017468)
Bumper	Chart Inc. Under-Ride (Meets FMVSS/CMVSS)
Fenders	
Front	
Rear	Stainless Steel
Front Mud Flaps	
Rear Mud Flaps	Anti-Sail, Black, Plain
Hose Tube	
Size/Material	PVC 8" Pipe Sch. 40 w/Stainless Steel Liner
Doors	Alum. Door for PVC Tube - Front (rear open to rear cabinet)
Delivery Hose	Chart Supplied - 21983270, LH2 VJ FLEX HOSE, 175PSI, 16FT, ACME #7875 (B31.12) - HQK
Piping Details	
Gas Phase Withdrawal Valve	ACME 2" Globe, Manual, SS, Bellows, Non-VJ
Liquid Fill/Withdrawal Manual Valve	ACME 2" Globe, Manual, SS, Bellows, VJ
Liquid Fill/Withdrawal Auto Valve	ACME 2" Globe, Air Operator, SS, Bellows, VJ
PB Liquid Phase Manual Valve	ACME 1-1/2" Globe, Manual, SS, Bellows, Non-VJ
PB Gas Phase Manual Valve	Rego/Goddard 2" Gate, Manual, SS, Non-VJ
PB Liquid Phase Auto Valve	ACME 1-1/2" Globe, Air Operator, SS, Bellows, Non-VJ
Metered Withdrawal VALVE	ACME 2" Globe, Manual, SS, Bellows, VJ
Vent Valve	ACME 1" Globe, Manual, SS, Bellows, Non-VJ
Liquid Phase Connection	2" Linde HQK Bayonet
Gas Phase Connection	2" Linde HQK Bayonet
Liquid Withdrawal Connection	2" Linde HQK Bayonet
Road Relief	(3) Cashco Backpressure Regulators (set @ 17psig, 35 psig & 155 psig)
Container Relief	Primary: Relief Valve / Secondary: Relief Valve
Diverter	3" 3-Way Ball Valve
Thermal Reliefs	1/4" Circle Seal Relief
TC Tube	Hastings DV6R
Vacuum Valve	ITT 1-1/2" Diaphragm Valve
Safety Equipment	
Helium Fire Abatement System	No Helium Fire Abatement System
Bayonet Flag System	Locks brakes when lowered
Emergency Air Valve Switches	Bendix TW-3 Toggle Valve E-Stop: (1) RS Front, (1) RS Rear, (1) CS Rear, (1) Rear Compartment
Emergency Valve Air Supply	Air supplied when tractor air is connected to green gladhand or customer air is connected to CP1
Wheel Chocks	Aluminum Chocks with SS Chock Holder Bracket
Safety Cone	Holder Bracket and Cone on Road Side
Fire Extinguisher	ANSUL# I-A-30-G-1
Placard Holder	None

Pressure Building Coil	
Connection	Welded
Rating	300 gpm
Product Meter	
Meter	Turbines Inc. HMC0200
Monitor	Turbines Inc. CDS1000-TPC-H2-EX
Paint	
Paint	PPG
Decals	Regulatory, Chart Inc. and Customer supplied