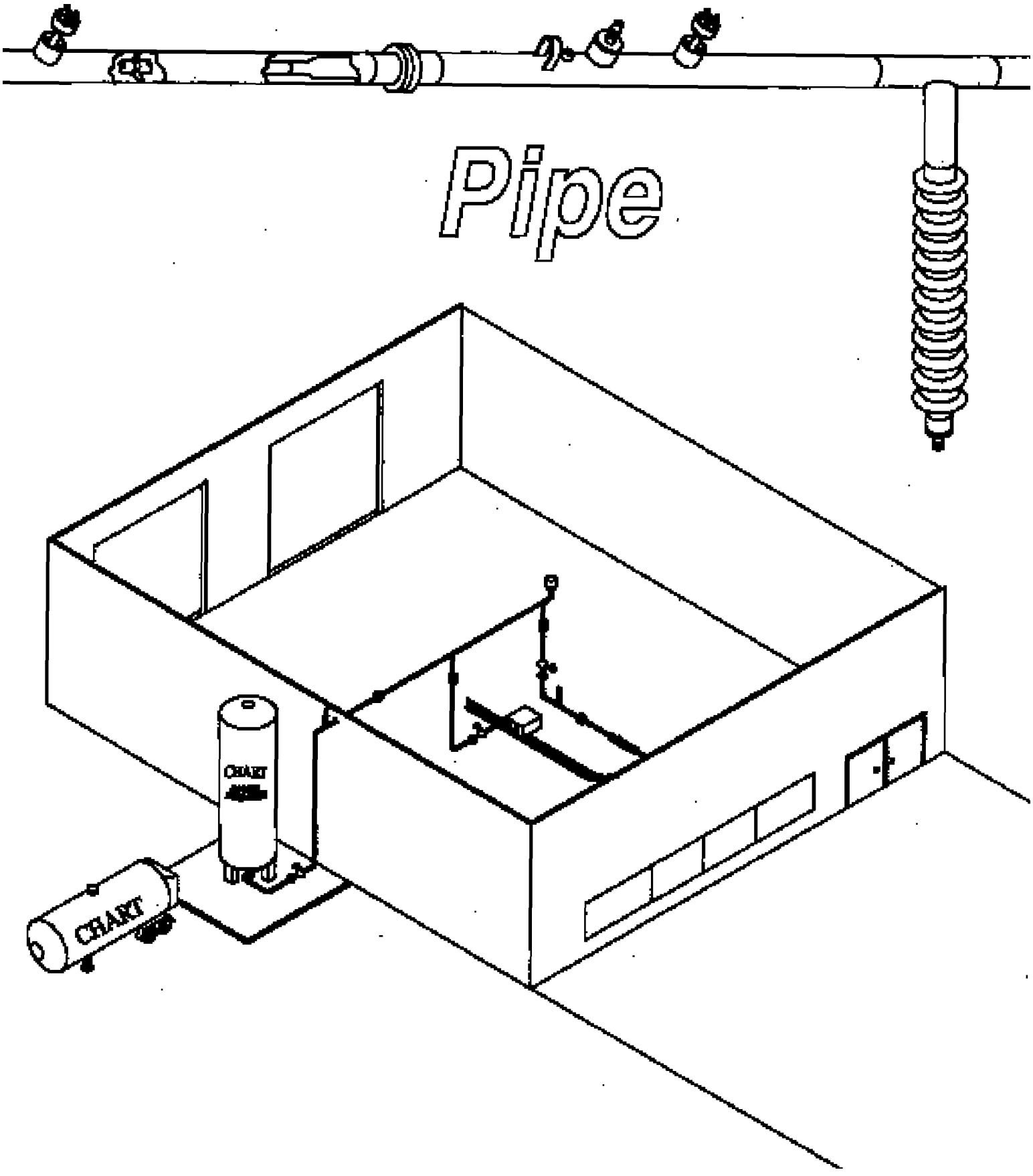
Vacuum Insulated Pipe



Built to Order Components

Since 1966 CHART (formerly MVE) has specialized in the design and fabrication of custom cryogenic piping for liquid nitrogen, oxygen, argon, helium, and hydrogen in pipe sizes ranging from 1/4" through 8".

CHART will continue, as always, to provide the finest available Vacuum Insulated Pipe (VIP), built to customer specifications.

Configuration (Size Limitations)
The configuration of a **Built to Order** section of VIP is restricted only by shipping and installation constraints. Typically, installation conditions impose more limitations than do shipping constraints. For shipping purposes, all pipe sections should fall within an 8 x 8x 40 foot envelope.

Approach to system design and specifications...to define your system needs.

- **Determine the basic routing** of the liquid nitrogen system. Chart will provide any needed assistance.
- **Develop an isometric sketch or plan and elevation views** of the vacuum insulated pipe (VIP) layout. This step is necessary to determine the exact components required.
- **Size the pipe and components** by determining expected current and future flow rates. CHART can assist once the flow requirements are known. Plan **now** for potential system expansion.
- **Be sure to note wall penetrations** so that couplings are positioned properly for ease of assembly.
- **Installation restrictions** for length of sections should also be noted.

Rigid vs. Flexible VIP

Rigid VIP has lower heat leak and is less expensive than flexible VIP.
The prudent use of flexible VIP sections...

- Minimizes alignment problems during installation and operation.
- Eliminates the necessity of precise field measurement.
- Provides simple means for disassembly of system for service or modification.

Valves used at the end of a run or drop are normally extended packing cryogenic valves. Vacuum jacketed valves are more expensive, and should be limited to in-line service.

Features of a typical system include...

- Bayonet couplings for ease of installation.
- Equivalent flow flexible sections for changes of direction and elevation.
- Vacuum jacketed in-line valves to insolate branch runs for selective shutdowns.
- Capped bayonet couplings for future expansion.
- Flexible drops with internal trapped ends for efficient operation and rapid response to cycling equipment.
- CryoVent at end of run to keep main header cold and liquid readily available to use points.

VIP Design Guide

Use Point Consideration
Operating efficiency is greatly affected by the design of use points. Because of the cyclical mode of operation in most applications, gas traps should be incorporated to keep cryogenic liquid out of the non-vacuum insulated segments of the system between use cycles.

Multiple use point configurations should be designed as illustrated in Figures D-2 and D-3.

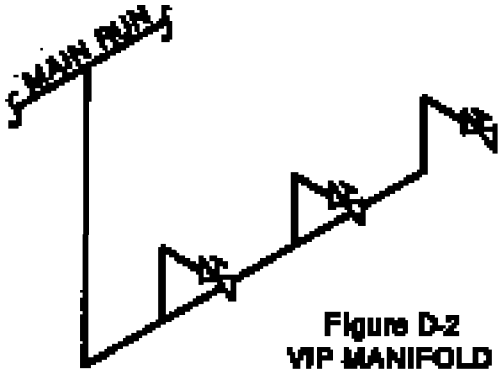


Figure D-2
VIP MANIFOLD

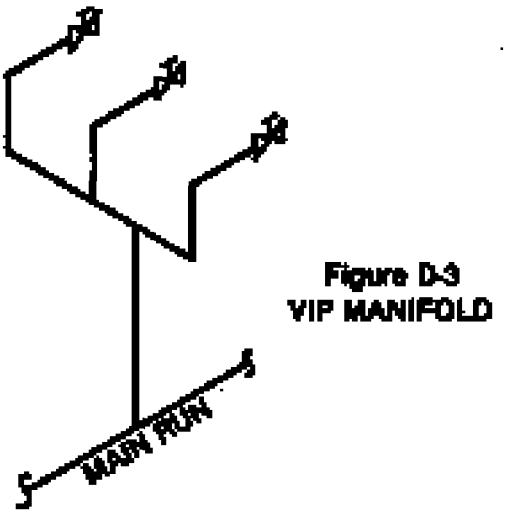


Figure D-3
VIP MANIFOLD

Trap End
Single drop use points also require trap ends. While Figure D-4 shows a suitable trap end installation the preferred method is the CHART Trap End as illustrated in Figure D-5. This is less expensive and requires less space than that illustrated in Figure D-4.

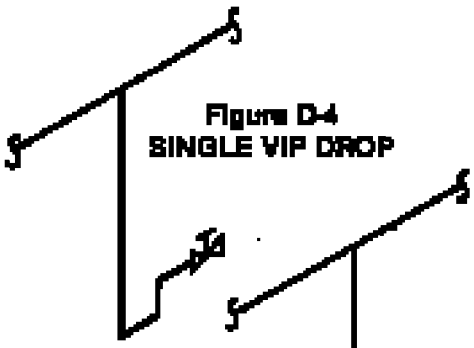


Figure D-4
SINGLE VIP DROP

Figure D-5
VIP DROP WITH TRAP END

Liquid Cryogen System Specification

A. Scope

This specification describes the requirements for vacuum insulated piping (VIP) line system for transfer of_____. (Specify) System layout and details as shown on customer supplied drawings.

NOTE: Contact CHART for assistance in system design.

B. Description of System

The vacuum insulated piping system shall be composed of prefabricated sections or “spools” of the static vacuum design with a chemical gettering system. The spools shall have CHART bayonet end connections for assembly in the field without welding. (Field weld assemblies upon request). Unless specified on the submitted drawings, CHART shall designate bayonet locations for customer approval. For consideration of price, installation, and shipping, no spool will exceed 40 feet in length or 8'0" in width.

1. Flexibility

Prudent use of flex hose shall be exercised because of higher heat influxation. If needed for a stainless steel bellows design external installation, it may be used in a lateral-offset manner to eliminate overstress conditions.

2. Supports/Hangers (supplied by others)

a. INVAR inner - any type.
b. Stainless steel inner (with internal bellows) - any type
c. Stainless steel inner (with external bellows) - must be a type which allows axial movement.

CHART shall provide anchor points of double wall reinforcement if required.

NOTE: Welding directly to jacket wall is not recommended.

C. Drawings

CHART shall submit a construction drawing for customer approval. Drawing to have sufficient dimensional and informational data for customer interpretation.

D. Design Criteria

1. Inner Carrier

The design and manufacturing of the VIP shall be in accordance with ANSI B31.3 - Chemical Plant and Petroleum Refining Piping and latest applicable addenda for 150 PSIG.

a. Material shall be “INVAR 36” or 304 stainless steel, ASTM A312 pipe, welded or seamless.
b. Flow Rate shall be as specified on drawing(s).
c. Size shall be as specified on drawing(s). Contact CHART for assistance.
d. Pipe Ends shall be CHART bayonet joints for joining spools and as specified on drawing(s) at use point(s).
e. Internal Bellows - Required when stainless steel inner carrier pipe is used. This eliminates the need for jacket expansion joints. CHART installs this item to compensate for the differential rates of expansion between inner carrier pipe and outer jacket.

2. Vacuum Jacket
Shall be designed in accordance with the ASME Code for Unfired Pressure Vessel, Section VIII for an internal vacuum and external atmospheric pressure with the assembly at ambient temperature.

a. Material shall be 304 stainless steel, ASTM A312 welded pipe.
b. Expansion Joints - **NOTE:** Only required when stainless steel inner carrier is used. Shall be installed in the jacket pipe of each spool as required to compensate for the differential rates of expansion and contraction between the inner carrier and jacket pipe.
   - Material - Shall be Type 321 stainless steel with Type 304 stainless steel ends for butt welding.
   - Design - Normal movement with minimum design as follows:
     1. External Pressure: 20 PSIG with internal vacuum.
     2. Internal Pressure: 35 PSIG.
     3. Cycle Life: 5000 cycles.
   - **NOTE:** Not required if internal bellows are used.

E. Vacuum Annulus

1. Spacers
The inner carrier shall be supported within the jacket by a support system designed to absorb thermal loads on the inner pipe when partially or completely filled with product minimize heat leakage, withstand loadings (a), (b), and (c), listed below during shipping, and loading (d) during and after installation.

a. Three "g" load applied vertically downward.
b. Three "g" load applied vertically upward.
c. Two "g" load applied horizontally, longitudinally, or laterally combined with one "g" load vertically downward.
d. Meet uniform building code for Zone 3 seismic requirement when inner line is filled with Trichlorethylene.

2. Laminar Radiation Shielding
The inner line shall be "super insulated" with a minimum of twenty alternate layers of aluminum foil and cryogenic paper.

3. Chemical Gettering System
Each spool shall have molecular sieve and a hydrogen converter installed in a vacuum annulus for the purpose of removing the majority of vacuum contaminants released by outgassing. The quantity of sorption pumping materials required for each spool section shall be determined by CHART.

4. Evacuation Port
Each spool shall be equipped with a CHART combination evacuation/relief valve port complete with a Hastings DV-6R Vacuum Transducer for monitoring the vacuum annulus.

a. Location shall be in an approved location or approximately centered on each spool with consideration to personnel safety, accessibility, and non-interference with other equipment.

F. Manfacturing
Shall be accomplished through the use of certified welders. Welder's certification to be submitted upon request.

G. Evacuation
Heat shall be applied during pumping to accelerate outgassing. Minimum temperature shall be 200°F. Spools to be sealed at less than 10 microns.
a. Means shall be employed on the vacuum pumping system to prevent oil from backstreaming into the spool vacuum space.

H. Cleaning
Procedures shall be submitted for customer approval.

I. Testing
All welds shall be leak-tested with a helium mass spectrometer calibrated to a sensitivity of 1×10^{-9} standard cc/second. Optional techniques are as checked below:

____a. _____% Liquid Dye Penetrant.

____b. _____% Radiographic x-ray.

____c. Pneumatic at 1.25 or Hydrostatic at 1.5 of Design Pressure.

____d. Liquid Nitrogen Cold Shock.

1. Vacuum Retention Test
Each spool shall be tested over a two day period with the spool isolated from the pump at ambient temperature. The pressure in the annulus space shall be measured every 24 hours and recorded. Spools will be acceptable if:
a. There is a pressure rise of eight microns or less. A pressure greater than eight microns will require one additional day of vacuum retention. The line shall be considered acceptable if the third day's reading indicates the vacuum is stable.
b. The maximum stabilized pressure before shipping is 35 microns. (Consult factory for seven day or greater retention.)

Manufacturing/ Quality Assurance

Chart designs and manufactures Vacuum Insulated Pipe (VIP) in accordance with the ANSI Code, Section B31.3, Chemical Plant and Petroleum Refining Piping.

Inner Pipe
Materials

- Invar—a 36% nickel alloy with an extremely low coefficient of expansion and contraction. Allows cooling pipe from room to cryogenic temperatures without expansion joints to prevent overstress.
- Type 304 stainless steel welded pipe—an excellent material for cryogenic piping. Requires expansion joints to prevent overstress at cryogenic temperatures.
- Stainless steel flexible tubing—provides flexibility and reduces stress at cryogenic temperatures.

Pressure Rating

- Standard pipe through 2" pipe size rated 150 PSIG maximum operating pressure.
- Piping rated for higher pressures can be manufactured on special order.

Outer Pipe (Vacuum Jacket)
Materials

- Type 304 stainless steel welded pipe.
- Stainless steel flexible tubing.

Insulation
Multi-layer super insulation—alternating layers of cryogenic paper and aluminum foil.

Manufacturing/ Quality Assurance

Vacuum System

Components

- Molecular sieve and hydrogen getter for long term vacuum maintenance.
- Relieving type evacuation valve.
- Thermocouple vacuum gauge tubes.

Evacuation

- Heat is applied during pumping to accelerate outgassing.
- System sealed at 10 microns or less in heated condition.

Testing

- All welds leak-tested with a helium mass spectrometer calibrated to a sensitivity of 1 x 10^{-9} standard cc/second.
- Two-day vacuum retention test to verify leak testing and seal off.

Final Inspection

- Vacuum reading.
- Visual check.
- Dimensional check.

Crating and Shipping

- Regular orders crated for protection of components and shipped via common carrier.
- Rush and/or larger orders—pipe shipped via dedicated truck to minimize handling and transit time.

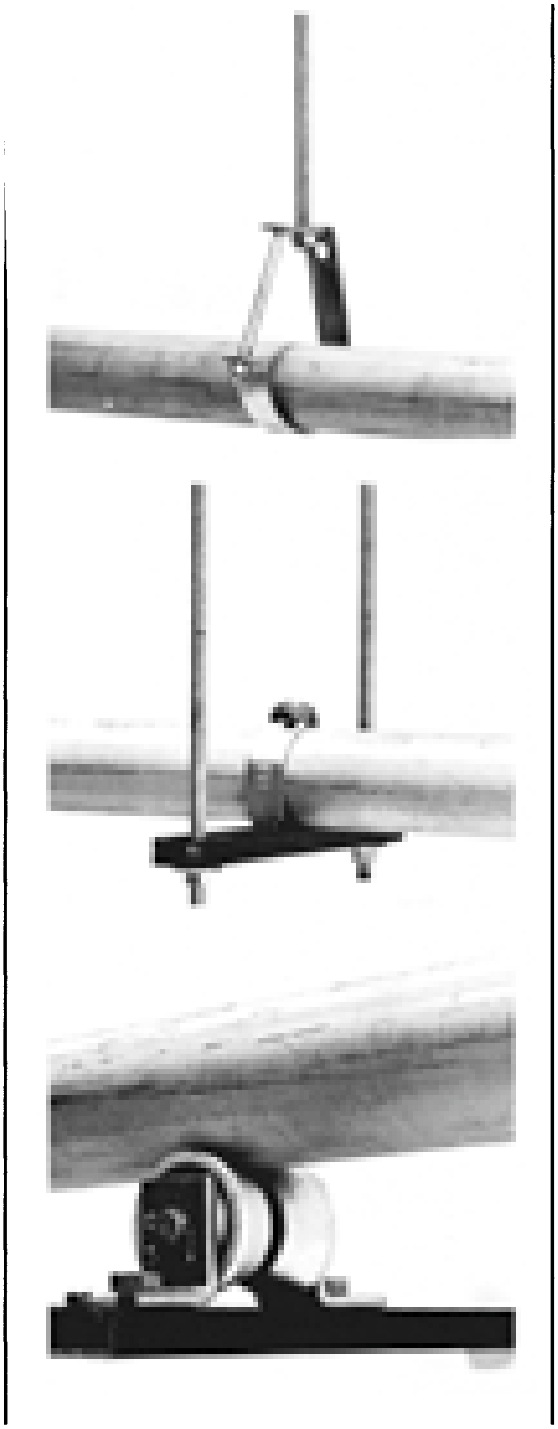
Installation Guide

Receiving Inspection

- **Exercise care** in unloading and uncrating.
- **Visually inspect all components** for physical damage. If damage is noted...
  - Immediately **initiate freight claim with carrier**.
  - **Notify your CHART representative** or the factory for disposition/assistance.
- **Read vacuum on each section of pipe,** using Hastings Vacuum Gauge, Model TV-4A. Report to CHART any vacuum pipe reading higher than 35 microns.
- **Clean bayonet couplings and O-ring** using clean, lint-free cloth and approved solvent. Inspect bayonet for damage. If deep scratches or dents are noted, **do not** install bayonet couplings. Contact CHART for assistance.

Hanging/Securing Pipe

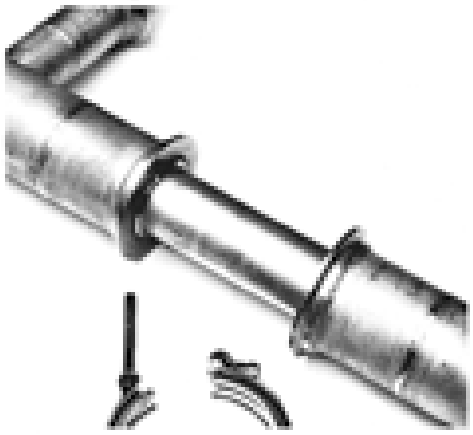
- **Install hangers and supports** at intervals of 6 to 10 feet, and at **all** change of direction points.
- **Use J-hangers, U-bolts, split clamps or roller type supports.** Exact type of hanger is determined by type of installation.
- **Select first section to be installed** (usually at one end of the system) and place **loosely** in supports.
- **Place adjacent pipe section in supports.**
- **Check alignment** before engaging bayonets.



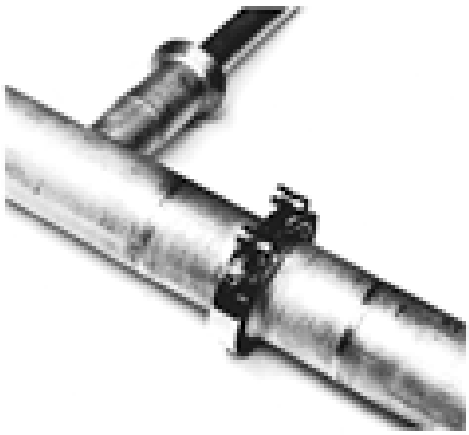
Installation Guide

- Lightly grease O-Ring with an approved grease for oxygen service (if applicable). Place in groove.

- Insert male bayonet into female bayonet. Complete engagement. NOTE: Do not twist either end during engagement. This could cause galling.



- Install bayonet clamp and tighten as follows:
  ½" - 50 in. lbs.
  1" - 50 in. lbs.
  1½" - 60 in. lbs.
  2" - 75 in. lbs.



Installation Guide

Do not tighten pipe support clamps firmly at this time.

- Continue installing adjacent pipe sections until all are in place.
- Make minor adjustments in support elevations to align system properly and to impose proper slope. Slope is normally back toward the nitrogen supply tank.
- Minimize elevation changes to prevent gas trapping in pipe.
- When system is properly aligned and essentially stress free, secure supports, allowing freedom of movement as follows...

  Installations exposed to extremes of ambient temperature must permit movement of pipe jacket.

  CAUTION

  Rigidly fixing the entire run may cause high stress at the bayonet couplings, resulting in possible leakage.

  Installations with Bellows-type expansion joints in the jacket pipe require freedom of movement for inner pipe contraction during liquid nitrogen flow.

Installation of Accessory Components
After the pipe has been installed and secured, the following accessory components may be installed.

- Valves
  Use point valves
  Relief valves
- Cryovent
  Assemble and install.
  Pipe exhaust to a safe area (outside if possible).

Tie-in to Liquid Nitrogen Tank

- Make-up piping from end of VIP to liquid withdrawal valve on supply tank.
- Conduct leak test. (See Testing—Pressure Hold Test)
- Jacket make-up piping with PVC jacket. Use jacket with outside diameter 4 or more inches larger than make-up pipe.
- Pour urethane foam into PVC jacket to minimize heat leak in non-vacuum jacketed part of the system.

Testing

- Pressure Hold Test
  After installation of all components (standard and accessory), pressurize entire system with dry nitrogen gas to maximum operating pressure or pressure designated by owner. Do not exceed 1.25 times VIP pressure rating. There should be no pressure decrease in piping system in a four-hour period.

  If pressure drops within a four-hour period, bubble test entire system, starting at supply tank, until leak is located and repaired.

  Repeat testing procedure until pressure hold test is successful.

Installation Guide

- **Cooldown test introduce liquid nitrogen** into piping system from supply tank.
- **Open valve at use point farthest from supply tank.** Allow nitrogen gas to flow until liquid nitrogen begins to issue from valve. Close valve.
- **Repeat procedure at all use points** until entire system is cooled to operating temperature.
- **Visually inspect** entire VIP system for condensation or frost formation. Frost at non-vacuum jacketed segments is normal. Contact CHART for assistance if abnormal frost formation or condensation is noted.
- **Functionally test accessory components for proper operation.**

When all tests have been successfully completed, the liquid nitrogen distribution system is ready for user operation.

Trouble Shooting Guide

Although rare, it is possible to have a problem with any vacuum insulated component. If a potential problem is noted, please contact CHART for assistance. The following trouble shooting guide is offered to facilitate evaluation.

Problem	Possible Causes	Action
Condensation or frost on pipe sections	Vacuum deterioration Thermal short Physical damage	Check vacuum and visually inspect for damage Consult CHART
Ice formation at bayonet flange	Vacuum deterioration Bayonet damage Flange o-ring damage	Check vacuum Consult CHART
Occasional condensation at bayonet flanges	Normal occurrence under certain temperature and humidity conditions.	If excessive/persistent, note temperature, humidity, consult CHART

Components for Liquid Withdrawal with Minimum Product Loss

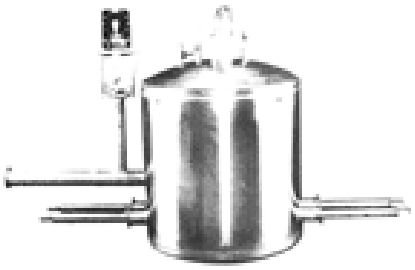
CryoVent Device
This fully automatic device utilizes a completely mechanical float system to maintain liquid in the line. The stainless steel inner vessel is vacuum jacketed and super insulated. Bayonet mounting allows the unit to be removed and reinstalled at the end of an expanded system.

Phase Separators
CHART solves the problem of high pressure liquid nitrogen discharge at use points with phase separators in a variety of configurations. By venting the excess gas generated from depressurizing liquid nitrogen, the phase separator provides low pressure, high quality liquid.

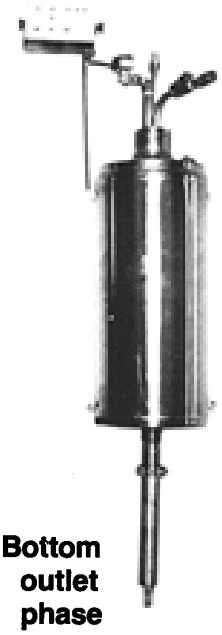
High and low level sensors govern automatic filling and incorporate an audible and visual alarm to notify operators of supply or equipment problems. An optional adjustable vent regulator provides optimum use point pressure up to 10 PSIG.

Three phase separator configurations are available: a bottom outlet unit for overhead mounting; a multiple outlet overhead model with four discharge lines; and a floor level model. All phase separators features stainless steel construction and low evaporation rates.

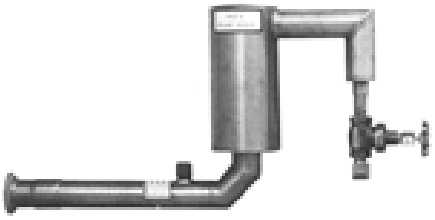
Subcooler
Systems operating at high pressure and high volume users will benefit from the CHART subcooler that lowers the cryogenic liquid's temperature prior to liquid withdrawal. A cryogenic bath subcools incoming liquid for distribution in the system. A subcooler is advantageous in systems that require elevation changes and continuous liquid withdrawal at use points.



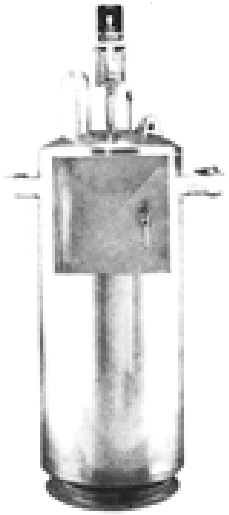
Multiple outlet phase separator



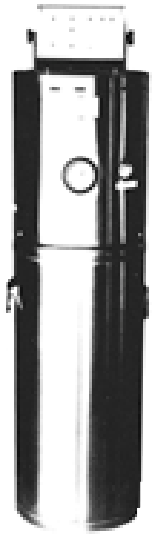
Bottom outlet phase separator



Cryovent device



Subcooler



Floor mount phase separator

Phase Separators Data Sheet

1.) Single Use Point

a) Floor Model

Tare Weight	65 Pounds
Height	45-1/2 Inches
Diameter	12 Inches
Capacity	24 Liters
LN2 Boil Off	1.5 Liters/day.

Fill Rate
Syst. Pressure 50 Psig
3.4 Liters/min.
Syst. Pressure 100 Psig
4.9 Liters/min.

Withdrawal Rate

At 5 Psig	1.7 Liters/min.
At 10 Psig	3.9 Liters/min.

b) Overhead Model

Tare Weight	60 Pounds
Height	41 Inches

Withdrawal Rate
Head Pressure Only
10 Liters/min.

2.) 4-Outlet

Tare Weight	135 Pounds
Height	36-1/2 Inches
Diameter	20 Inches
Overall Length	50 Inches
Capacity	46 Liters
LN2 Boil Off	6.1 Liters/day

Fill Rate
System Pressure 30 Psig
5.2 Liters/min.
System Pressure 120 Psig
9.5 Liters/min.

Withdrawal Rate/Opening
Head Pressure Only
4 Liters/min.

VIP Maintenance Instructions

The static vacuum super-insulated cryogenic piping system has been designed, manufactured, and tested for long life trouble-free and maintenance free application. As with any mechanical and/or chemical device, malfunction may occur.

Periodically (i.e. 6 months/12 months) a visual examination of the entire system should be made and note any section that has condensation, ice spots, etc., starting to form. Also note ambient temperature and humidity level. This section should then be monitored weekly/monthly for indication of frost formation. (If equipped with a vacuum transducer a vacuum level reading may be obtained.)

Frost or sweat formation may occur:

1. At all uninsulated end use terminations.
2. At bayonet flanges, given certain temperature and humidity conditions.
3. On pipe sections depending on vacuum level, temperature, or humidity conditions.

If sweat or frost does occur on a section and does not disappear with a change to lower humidity and temperature consult the factory for proper procedure to follow.

NOTE: On each section of VIP, a CHART label is located by the seal-off device. This label contains the “customer name”, “VS#” (vacuum section number), and the order number the line was built under; please furnish this information whenever consulting the factory about this system.

Any time a section or component is returned to the factory a customer return authorization number must be obtained.

A World Leader
In The
Design & Manufacture Of Cryogenic Equipment

- Portable Cylinders and Transport Vessels (5 liters through 7600 gallons)
- Storage Tanks (300 gallons through 80,000)
- Cryobiological Freezers and Shippers
- Vacuum Insulated Pipe
- Liquid Helium Shippers and Transfer Tubes

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