NASA SP-5932 (01)

TECHNOLOGY UTILIZATION

CRYOGENICS

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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TECHNOLOGY UTILIZATION OFFICE 1970
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

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Foreword

The National Aeronautics and Space Administration and Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace and nuclear research and development programs.

This publication is part of a series intended to provide such technical information. A selection has been made of items pertaining to cryogenic technology. Applications range from cyrogenically cooled masers to a method of expediting pipe repair by freezing outer boundary sections. Materials and devices are discussed in terms of durability and reliability under extreme temperature stresses.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader's Service Card included in this compilation.

Unless otherwise stated, NASA and AEC contemplate no action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

Ronald J. Philips, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

Contents

Section 1. Materials

EVALUATION OF A FLUOROCARBON PLASTIC USED IN CRYOGENIC VALVE SEALS

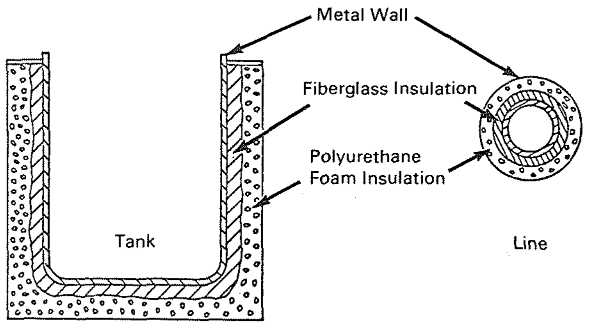
Tests were conducted to determine the independent and interacting effects of strain rate, temperature, crystallinity, and surface finish (smoothness) on the tensile strength of a commercial chlorotrifluoroethylene plastic (CFTE) used for lipseals in very fast-acting liquid oxygen valves. Approximately 200 tests were performed at strain rates between 0.02 and 10,000 inches per minute and temperatures of 75° and –320°F. Emphasis was placed on obtaining mechanical property data over a wide range of strain rates at cryogenic temperatures to determine if the effects of crystallinity and surface smoothness are greater at high strain rates than at low and medium strain rates.

The analysis showed that the environmental factors (temperature and strain rate) were more significant than the material properties (surface finish and crystallinity). Effects of high strain rate on tensile strength differed for ambient (75°F) and cryogenic temperature (-320°F). The specimens appeared to fail in a two-step process at a strain rate of 10,000 inches per minute. From the accumulated data, however, it was concluded that machined medium-crystallinity seals can be used as a less expensive replacement for molded low-crystallinity seals in fast-acting cryogenic fluid valves.

Source: R. E. Cierniak, J. H. Lieb, and R. E. Mowers of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-18189)

Circle 1 on Reader's Service Card.

FIBERGLASS PREVENTS CRACKING OF POLYURETHANE FOAM INSULATION ON CRYOGENIC VESSELS



When vessels are cooled to cryogenic temperatures, differential shrinkage causes polyurethane foam insulation to separate from metal surfaces. Voids between the separated polyurethane insulation and the metal surfaces become filled with moisture and air (in liquid or gaseous states, depending on temperature) and cause damage to the insulation.

The interposition of a layer of fiberglass insulation between the polyurethane foam insulation and the outer surfaces of the cryogenic lines and tanks prevents shrinkage. The fiberglass material retains its resilience at cryogenic temperatures and provides an expansion layer between the metal surfaces and the polyurethane foam, preventing cracking of the latter.

Source: D. A. Forge of McDonnell Douglas Corp. under contract to Marshall Space Flight Center (MFS-20058)

No further documentation is available.

PANELIZED HIGH PERFORMANCE MULTILAYER INSULATION

A composite insulation covering possessing desirable cryogenic insulation properties, venting characteristics, and high energy particle absorption qualities, is available for cryogenic-fluids storage tanks and mobile tankers. This multilayer covering has low conductivity foam spacers interleaved between layers of aluminized 1/4-mil polymer film radiation shields. It is faced with a high density jacket which is resistant to penetration damage.

Source: R. A. Burkley and C. B. Shriver of
Goodyear Aerospace Corp.
under contract to
Marshall Space Flight Center
and J. M. Stuckey
Marshall Space Flight Center
(MFS-14023)

Circle 2 on Reader's Service Card.

PHYSICAL STABILITY TESTING OF CRYOGENIC TANK INSULATION

An inexpensive testing procedure has been developed for the evaluation of potential cryogenic insulation composites by both manufacturers and users.

Historically, the physical stability of cryogenic vessel insulation has been a serious problem. Insulation liners used on liquid hydrogen tanks are required to withstand considerable stresses from thermal shocks imparted to the insulation during the filling and draining of tanks. To determine the effects of these stresses, the test cyclically subjects the specimens to thermal shock so that the damage can be measured.

Specimens of the insulation composite to be tested are bonded to plates of a metal having a very low coefficient of thermal expansion. The resultant units are then immersed in a cryostat containing liquid hydrogen for approximately 5 minutes, removed, and kept at room temperature for at least 5 minutes. This procedure of thermally shocking the specimens is repeated for 10 cycles. The number of cracks and the extent of damage on the insulation composites are visually observed and recorded at the end of each cycle for further analysis of the test results.

Source: D. Rossello of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-12547)

Circle 3 on Reader's Service Card.

THERMAL EXPANSION PROPERTIES OF FLUIDS

The thermal expansion properties of fluids have been compiled into a single handbook. Thermal expansion vs temperature curves for fluids from −423°F to 2000°F are presented in two sections, one covering cryogenic temperatures (down to −423°F), and the other dealing with elevated temperatures to 2000°F. The curves are intended to supplement the accuracy of computations using linear thermal expansion coefficients by permitting the direct determination of the total thermal length change between any two specific temperatures. Descriptions of test procedures and analyses of the measurements are also included in the handbook.

Source: E. F. Green of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18335)

Circle 4 on Reader's Service Card.

FIBERGLASS-REINFORCED STRUCTURAL MATERIALS

Properties of fiberglass-reinforced plastic materials with potential application as tension supports for cryogenic tanks have been extensively investigated. These materials are of particular interest because of their low density, unidirectional strength, low thermal conductivity, and ease of fabrication. Tension rods, tubular struts, and "I" beams manufactured from epoxy resins with fiberglass reinforcements were evaluated and compared with their metallic counterparts to determine the thermal and weight advantages of using fiberglass-reinforced plastic structures. Beams were considered as payload support members where lightweight rather than low thermal conductivity was of primary importance. It was found that deflections are greater and stiffness less for fiberglass materials than for comparable metallic parts.

Therefore, in cases where stiffness design criteria prevail and thermal conductivity is not a factor, advanced composites employing filamentary materials bonded with epoxy resins may be competitive with metallic materials.

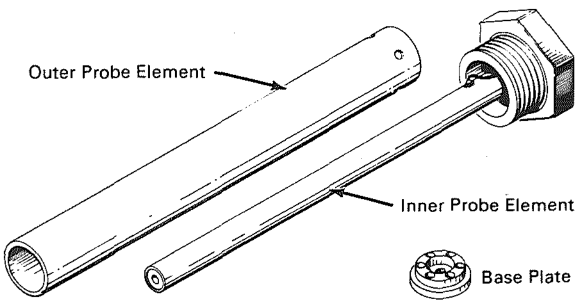
Source: D. H. Bartlett of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-14806)

Circle 5 on Reader's Service Card.

Section 2. New and Improved Devices

CRYOGENIC LIQUID LEVEL MEASURING PROBE

Static and dynamic levels of cryogenic liquids in a hydrogen bubble chamber can be measured by a newly developed universal liquid level measuring probe. This device incorporates a unique



frequency discriminator to provide continuous readings of the levels of nitrogen, hydrogen, or helium to an accuracy of ±1%. The probe has a dynamic response time of less than 150 μsec, allowing boiling conditions or other turbulence to be observed throughout all the transition stages.

The coaxial probe, when immersed in a liquid, measures the difference in the dielectric constants between the liquid and gas phases of the media. The probe capacity is therefore a function of the height of the liquid within the probe elements. The probe and its associated cable constitute the capacity in the tuned circuit of an oscillator, and a liquid level change is reflected as an oscillator frequency change. A voltage controlled oscillator is phase locked to the probe oscillator frequency. The error voltage required to keep the two oscillators phase-locked is then a function of the liquid level.

A percentage readout is used with the probe to provide more efficient use of the instrument's dynamic range and to reduce operator error. In addition, the system may be used as a data logger to record liquid levels in a number of containers through a scanning operation.

Source: J. A. Dinkel and C. R. Wegner
Argonne National Laboratory
(ARG-10138)

Circle 6 on Reader's Service Card.

SILICON STRAIN SENSORS FOR PRESSURE MEASUREMENT AT CRYOGENIC TEMPERATURES

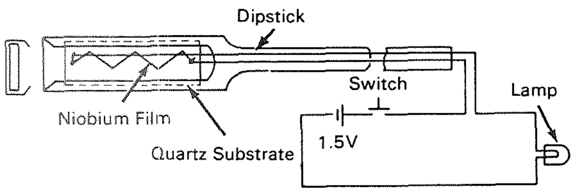
Diffused, heavily doped silicon strain-gage sensor elements have been developed for operation in pressure transducers over a wide temperature range. Improvement in gage characteristics, excitation source impedance, bridge circuit parameters, and transducer structure has led to the design of miniature pressure transducers which exhibit zero and sensitivity shifts of less than ±3% of full scale throughout the temperature range from +250° to −450°F. Small thermal mass combined with close coupling between a metallic diaphragm (force summing member) and sensor elements minimizes sensitivity to temperature transients. Silicon is selected as the semiconductor material because of its piezoresistive and mechanical properties. The piezoresistive behavior of silicon is also sufficiently well known to permit prediction of gage characteristics on the basis of impurity type and concentration. Although the sensors were developed for low temperature operation, they perform equally well at much higher temperatures and provide continuous measurement capability over a 700°F temperature range.

Source: R. Bowman, J. Burns, and W. McLellan of Electro-Optical Systems, Inc. under contract to Marshall Space Flight Center (MFS-14703)

Circle 7 on Reader's Service Card.

SUPERCONDUCTIVE THIN FILM USED AS LIQUID HELIUM LEVEL SENSOR

The level or depth of liquid helium in a dewar flask may be measured to an accuracy of ±0.25 inch by averaging two readings from a superconductive thin film sensor. The thin film of niobium



metal is deposited to a thickness of approximately 2000Å on a quartz substrate, which is then mounted on a graduated dipstick. The film deposition is performed at 600°F in a vacuum of approximately 10^{-6} torr (with an electron beam evaporation source) at an evaporation rate of approximately 1500Å per minute. For a sensor on a quartz substrate measuring 1/16 ×3/8 × 1 inch, the electrical resistance of the device is 200 ohms at room temperature.

In the measurement of liquid helium levels, the niobium film is connected in series with a 1.5 volt battery, an indicating lamp, and a normally open pushbutton switch. With the switch closed, the top of the dipstick is held with thermally insulated gloves and the sensor is slowly and cautiously lowered into the dewar until the indicator lamp lights. At this point, sensor contact with the liquid helium reduces the sensor temperature so that the niobium becomes superconducting. The loss of resistance in the sensor permits sufficient current to flow from the battery to light the lamp. The reading on the dipstick then corresponds to the liquid level. Once turned on, the lamp will remain lit (with the switch closed) as long as the sensor is immersed in the liquid or is surrounded by helium vapor immediately above the liquid surface.

Source: H. H. Becker Langley Research Center (LAR-10289)

No further documentation is available.

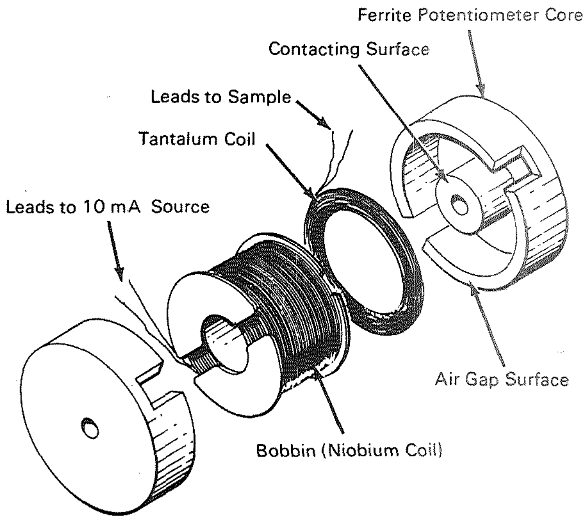
SUPERCONDUCTING SWITCH PERMITS MEASUREMENT OF SMALL VOLTAGES AT CRYOGENIC TEMPERATURES

Placement of a small, dual-coil, superconducting, on-off switch in a shunt configuration between the thermocouple (voltage source) at cryogenic temperatures and the measuring device at room temperature assists in the measurement of small voltages. Previously, the measurement of small, thermoelectrically generated voltages produced by thermocouples in a liquid helium bath was made difficult by spurious voltages. These relatively large, spurious, thermoelectric voltages are generated in the leads which connect the thermocouple with the measuring device.

When the switch is nonsuperconducting, the measuring device sees the sum of the voltage to be measured and the spurious thermoelectric voltages. When the switch is superconducting, only the spurious voltages are detected. The superconducting switch in combination with an appropriate potentiometer has a sensitivity of 1×10^{-9} volt.

The switch consists of two identical ferrite potentiometer cores. A bobbin with 800 windings of 0.005-inch-diameter niobium wire is placed between the potentiometer cores. The potentiometer cores are then screwed together and a coil of fine tantalum wire is wound noninductively into the air gap between the surfaces of the potentiometer cores. The 0.002-inch diameter tantalum wire is separated from the niobium by copper foil. Both the tantalum and niobium wires are teflon-coated.

In operation, the switch is immersed in liquid helium outside the vacuum can of a cryostat. The tantalum coil of the switch is connected to the thermocouple within a vacuum can via short pieces of niobium wire spot-welded to the tantalum wire. When no current passes through the niobium coil, the tantalum coil is superconducting (with a resistance of 1×10^{-5} ohm,), and the measuring device can only detect the spurious voltages. A current of 6 mA or more, passed through the niobium coil, activates the switch by causing the tantalum coil to pass into a nonsuperconducting state with a resistance of 45 ohms at 4.2°K. (The resistance



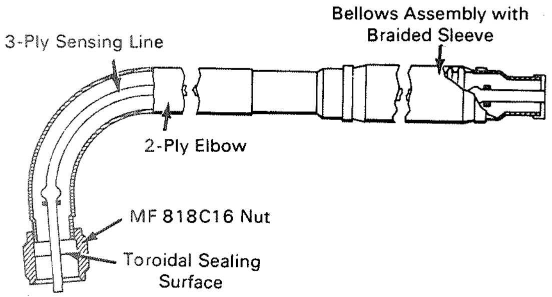
of the tantalum coil at room temperature is 1040 ohms.) In this state, the measuring device detects the sum of the thermocouple voltage and the spurious voltage since the tantalum coil impedance is very large relative to the output impedance of the thermocouple.

Source: R. P. Huebener and R. E. Govednick
Argonne National Laboratory
(ARG-90260)

Circle 8 on Reader's Service Card.

COAXIAL SENSING LINE

Improved performance in a high vibration environment is provided by a newly developed 1 1/4-inch diameter coaxial sensing line. The line was originally designed to convey sensing pressure and booster supply pressure from a liquid oxygen (LOX) tank to a two-stage (pilot/booster) control valve. The two functions are segregated by the coaxial design of the sensing line. If a single line served both functions, valve response would be slower since the booster flow is of such magnitude that it would result in an appreciable pressure drop across the length of the



line. The pressure sensed by the pilot would be lower than tank pressure, and the valve would not open as quickly and would begin to close prematurely.

As illustrated, a braided bellows is integral with the line to take up variation in attachment points, and to deflect during vibration. The elbow section is made of 2-ply stainless steel tubing, and the inner sensing line is made of 3-ply polytetrafluoroethylene tubing to provide natural damping during vibration. The inner tubing is light in weight, reducing the loads imposed on the outer coaxial line.

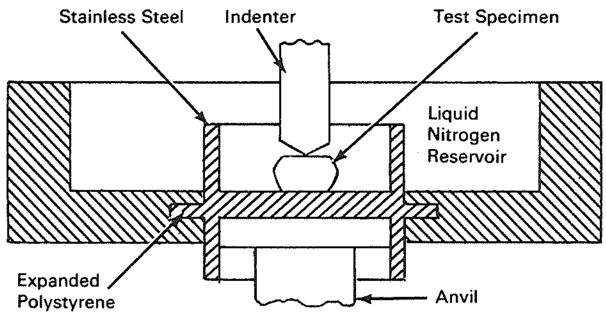
Source: D. Marley of
Parker Hannifin Co.
under contract to
Marshall Space Flight Center
(MFS-20637)

Circle 9 on Reader's Service Card.

CRYOGENIC HARDNESS TESTING DEVICE

Bearing components may be hardness tested at temperatures of -320° to 70°F by using a simple inexpensive device consisting of a cup-shaped stainless steel anvil and an enclosure made from closed-cell polystyrene or polyurethane. The enclosure is fabricated in two pieces for easier assembly and cemented around the anvil.

After the item requiring hardness testing is placed in the anvil cup, the cup and the surrounding plastic enclosure are filled with an appropriate cryogenic fluid. The part is allowed to reach the temperature of the cryogenic bath and hardness readings are taken with a conventional hardness tester.



Source: Marshall Dietrich
Lewis Research Center
(LEW-10956)

No further documentation is available.

CRYOGENIC FEEDTHROUGH

Temperature rise due to the heat-sink effect of cryogenic tank bulkheads may be minimized by a newly developed feedthrough. In this application, a number of conduits at essentially equal temperatures (but below that of the bulkhead) are placed in a feedthrough. The lengths of the conduits differ to accommodate connections to external lines.

The conduits are welded to a plate which is formed from annular rings to maximize the thermal length. The plate, in turn, is welded to a series of baffle rings or tubes which are concentric but not contiguous. These baffle rings are welded together at alternate edges to form a maximum-length thermal conduction path between the flange and the cold V conduits. The outermost ring is welded to the flange. The flange, with a gasket, is then bolted to the bulkhead.

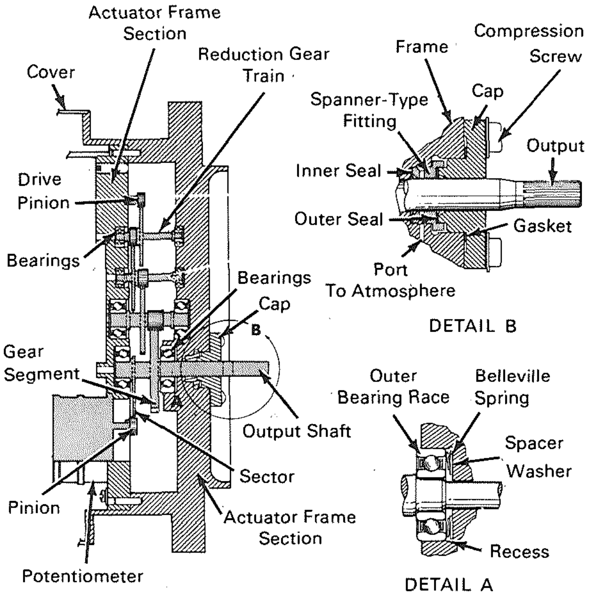
This feedthrough application is feasible in the storage of cryogens as well as in dynamic operating cryogenic or combination cryogenic/vacuum devices.

Source: S. P. Yager
NASA Pasadena Office
(NPO-90848)

Circle 10 on Reader's Service Card.

ELECTROMECHANICAL ROTARY ACTUATOR OPERATES OVER WIDE TEMPERATURE RANGE

Reliable operation of an electromechanical actuator over a temperature range of +140° to −300°F is made possible by avoiding the use of petroleum-based greases unsuitable for cryogenic applications. Dry lubricants are used for the gears while the bearings are unlubricated to prevent nonfunctioning at cryogenic temperatures.



The actuator incorporates a spring stop designed to limit internal deceleration loads to a magnitude equal to stall torque. To achieve accurate positioning of the stroke limit, the actuator unit comprises a reduction gear train, motor drive pinion, output shaft, and potentiometer as illustrated. Overtravel of the output shaft is below 1.50, which is less than a full revolution of the motor.

The entire assembly is environmentally sealed by welding a cover to the frame. To avoid penetration of fluids along the output shaft, inner and outer seals are provided. The area between the seals is ported to the atmosphere to drain any fluid passing the outer seal, and avoid the possibility of such material entering the inner sealed area.

Source: S. F. Sullivan of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18402)

Circle 11 on Reader's Service Card.

A LIQUID HYDROGEN INLET DISTRIBUTOR

Damaging stresses arising from the transfer of supercold liquid gases from a feeder line into a manifold system may be reduced by an internal spray distributor within the inlet header to provide an equalized chill-down of the inlet header and to minimize thermal distortion of both header and flanged joints.

Previously, temperature distribution to the vaporizer coils was uneven, causing the inlet header to bow excessively and to impose abnormal stresses on the flanged joints. The use of an inlet header diversion plate to improve fill and distribute the flow to the vaporizer coils was unsatisfactory. Consequently, the diversion plate and the flanges were removed from the inlet header and the internal spray distributor installed. By connecting the distributor to the liquid gas source, equalized cooling around the circumference of the inlet header was achieved. The distributor provides for the vaporization of the liquid being sprayed on the immediate areas of the inlet header resulting in equalized chill-down of the vaporizer system.

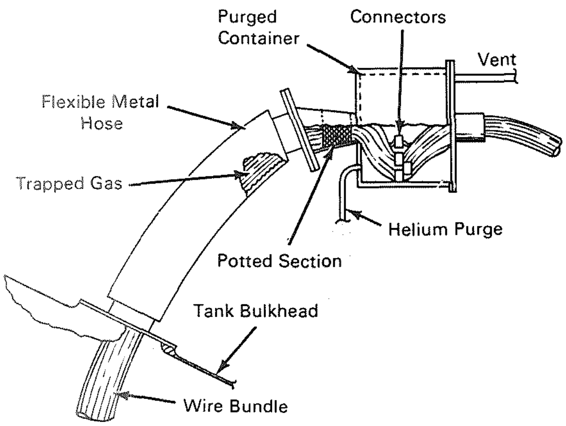
This device may be used in any application where supercold liquid gases are transferred from a feeder line into a system which is at ambient temperature.

Source: R. H. Roberts and W. J. Burns of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10380)

No further documentation is available.

STRAIN GAGE WIRE FEEDTHROUGH FOR CRYOGENIC PRESSURE VESSELS

Damage to a wire feedthrough exposed to cryogenic temperatures may be avoided by protecting the instrumentation wires from harmful gases and liquids. Routing the instrumentation wires from inside a cryogenic vessel may be safely accomplished by the use of a 5-foot long flexible hose over the wires, coupled with an inherent trapped gas barrier in the hose and a purge to prevent hazardous gas leakage.



Isolation of an electrical feedthrough from the cold pressure vessel prevents the electrical potting compounds from cracking or pulling away from the metal walls in cryogenic temperatures. As illustrated, this feedthrough was designed to mount on the top side of a pressure vessel, where no liquid would contact the flexible metal hose, and where the warmed gas inside the hose would be trapped as it is forced up by heavier gases below.

In common with the previously described feedthrough, this device is easily constructed and assembled from readily available standard parts and common materials.

Source: J. D. Hensen of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-15040)

Circle 12 on Reader's Service Card.

ELIMINATION OF SURGING FLOW CHARACTERISTICS IN LIQUID OXYGEN

The addition of a vent control system and a separate feed line network to the storage tank output line of a liquid oxygen (LOX) system eliminates the severe shock and vibration conditions normally experienced in the line chill-down (priming) process. In the redesigned system, LOX flows into the tank output line at its low point from the separate feed line. The existing ambient equilibrium pressure from gaseous oxygen in the tank line is gradually lowered by the vent control system, and LOX is allowed to enter slowly to avoid the undesirable impact energy of an accelerated high density fluid flow. Flow of LOX is determined by a differential pressure controller which signals the feed line valve to open or close according to preselected equilibrium pressure levels.

As described, the system can be operated either in a manual or remote mode. This improvement should be of interest to private industry engaged in storage and transfer of liquid oxygen, liquid nitrogen, or other cryogenic liquids having similar molecular weights.

Source: B. Drescher of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10016)

Circle 13 on Reader's Service Card.

CRYOGENIC CONTAINER THERMODYNAMICS DURING PROPELLANT TRANSFER

During initial phases of transfer of cryogenic liquids from dewar to receiver tank, such transient and complex thermodynamic phenomena as pressure surging and flow oscillations in the transfer line and pressure fluctuations in the receiver tank are evident. Since these phenomena have contributed to line rupture and receiver tank implosion, an exhaustive study has been performed using laboratory model analyses derived from empirical data fed to a digital computer.

Of particular interest in receiver tank performance is the reaction of tank pressure in early transfer phase to the average size of liquid droplets in the liquid/vapor jet entering the tank. It has been determined that the basic cause of tank implosion is the evaporation rate of droplets entering the tank in the early transfer phase. If the droplets are small, evaporation is rapid, and energy is removed from the vapor in the tank, causing a rapid drop in tank pressure.

To reduce the rate of pressure drop, a baffle is placed within the tank facing the inlet. The incoming liquid is then forced along the tank wall to reduce ullage-liquid heat transfer.

Source: R. M. Vernon and J. J. Brogan of
Lockheed Missiles and Space Co.
under contract to
Marshall Space Flight Center
(MFS-14310)

Circle 14 on Reader's Service Card.

LIQUID HYDROGEN STORAGE VESSEL WARM-UP

A systematic procedure for warming low pressure cylindrical vessels to ambient temperatures, in order to repair them, has been devised to avoid damages caused by uncontrolled warming. If cryopumped air is present in "Perlite-filled, vacuum-jacketed liquid hydrogen vessels," the inner tank must be emptied of the liquid hydrogen to prevent over-pressurization.

To initiate the procedure, it is necessary to install 1000-micron range vacuum gages and compound gages at the top and bottom of the vessel and to connect a high capacity vacuum pump (300 to 400 cfm) to the annulus vacuum system. The inner vessel is pressurized through the top inlet with hydrogen gas at 30 to 45 psig. Pressurization is then retained for 10 minutes to record the pressure shift and the vacuum readings of the annulus. This pressurization and release cycle is repeated approximately 12 times before the pressure shift has decreased to about 60% of its original volume and the vessel is in a liquid air temperature range. When the pressure decay in the annulus has decreased 33% of the original amount after about 20 cycles, the vessel should be above the boiling point of air and safe for faster warm-up.

This procedure provides a measure of safety during the repair and servicing of liquid hydrogen vessels by commercial users.

Source: W. M. Bowers and
W. B. Ingle of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18182)

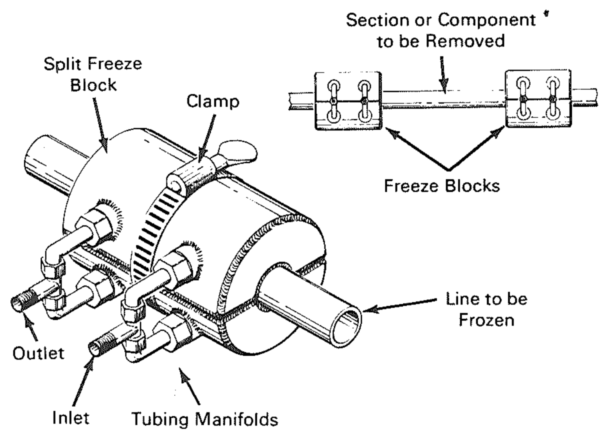
Circle 15 on Reader's Service Card.

Section 3. Applications

FREEZE BLOCK

Pipelines may be easily repaired without draining their fluid contents if the defective section is isolated by freezing the liquid contents on both sides of the defect. As illustrated, four semicircular aluminum jackets are constructed to fit the specific line size. These are equipped with inlet and outlet valves. Two jackets are clamped around the pipe to enclose a complete section on one side of the faulty joint or line, and two jackets perform a similar function on the other side.

A liquid nitrogen supply is connected to each inlet valve, and an exhaust line is joined to each



outlet valve. Liquid nitrogen (LN_2) is then circulated through the jackets until the liquid in the pipe is frozen. At that point, the repair work is accomplished. Upon completion of repairs, the nitrogen source and the jackets are removed so that the fluid flow can resume. Although this concept is not novel, the application of cryogenic fluid is inexpensive and easily performed.

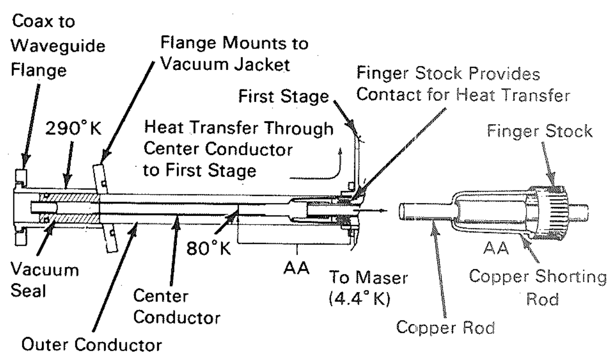
Source: J. T. Emmick of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11036)

No further documentation is available.

THERMAL SHORT IMPROVES SENSITIVITY OF CRYOGENICALLY COOLED MASER

An in-line quarter-wave thermal short may be used to cool the center conductor of a signal input coaxial transmission line to a cryogenically cooled traveling wave maser. This device reduces both the thermal noise contributed by the coaxial line and the heat leak through the center conductor to the maser which operates at 4.4°K. The ambient insertion loss of the short is 0.011 db. When cooled to 80°K, the device contributes less than 0.1°K to the maser noise temperature.

The figure on the right shows the thermal short installed in the transmission line and the manner in which heat is transferred through the center conductor into the closed cycle refrigerator. Refrigeration at the first stage is sufficient to cool the center conductor from ambient temperature (290°K) to 80°K along a 4-inch length. The thermal short (on the right) which is inserted into the transmission line is of such configuration that the heat from the inner conductor is transferred conductively at the rate of 400 mw through copper shorting rods to a finger stock contact to the outer conductor. The addition of the thermal short does not change the electrical characteristics of the line, having slight effect on the VSWR over a 25% bandwidth.



Signal Input Coaxial Line Assembly

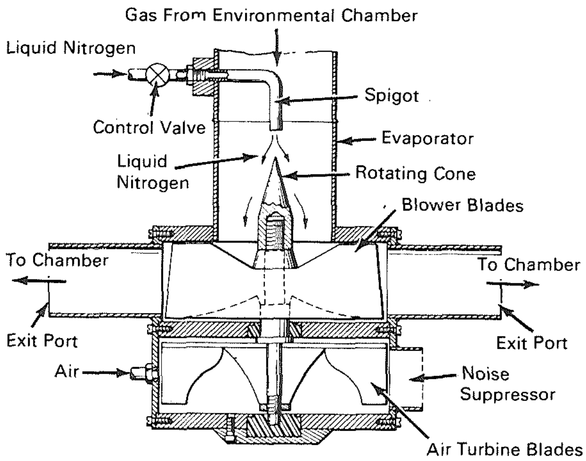
In-Line Quarter-Wave Thermal Short

Source: R. C. Clauss
NASA Pasadena Office
(NPO-09975)

Circle 16 on Reader,s Service Card.

DUAL-PURPOSE CHAMBER COOLING SYSTEM

Small environmental test chambers may be cooled with a temperature-controlled gas stream evaporated from a cryogenic liquid, such as liquid nitrogen. This system is particularly suitable for use at remote test sites where small tanks of cryogenic liquids can provide steady, regulated gas



streams. It is capable of reducing the temperature of a chamber to a desired point between the low temperature of the cryogenic liquid and the ambient temperature in a fraction of the time required by previous systems.

The evaporation zone may be combined with any standard high-velocity gas blower or turbine in this system. It operates in conjunction with a storage tank containing the cryogenic liquid whose flow is regulated by the control valve as illustrated. In start-up operation, the blower blades, which are driven by the air turbine, force the coolant gas to circulate through the exit ports from the blower into the chamber. Simultaneously, the gas in the chamber is drawn into the evaporator and then recirculated through the blower. The cryogenic liquid from the supply tank trickles from the spigot when the control valve to the evaporator is opened and partly evaporates as it impinges on the rotating cone which also serves as a flow divider.

This innovation may also be considered for operations involving detonating devices or high explosives contained in small test chambers.

Source: R. E. Fraze
NASA Pasadena Office
(NPO-10467)

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NASA-Langley, 1971

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