Final Report
Implementation of Advanced LCNG Fueling
Infrastructure in Texas along the
I-35 / NAFTA Clean Corridor Project

Submittal to:
Department Of Energy
Chicago Operations

Prepared by:
Blue Fuels Group L.P.
formerly Lone Star Energy Company
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Grand Prairie, Texas 75050

Contract # 9889

Submitted:
May 2001

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DOE Patent Clearance Granted

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Date

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Introduction

Project Background

Blue Fuels Group, L.P./Lone Star Energy Company Background Statement

Blue Fuels Group, L.P. (formerly Lone Star Energy Company), is a subsidiary of Blue Energy and Technologies, L.L.C., which was formed in August 2000, by the merger of Natural Fuels Company, formerly a division of Colorado Public Service Company, and Lone Star Energy Company, formerly a division of TXU (Texas Utilities). Combined the new company has designed an built over 70 compressed natural gas (CNG) stations for clients in Texas and Colorado, and 2 liquefied natural gas (LNG) stations for Dallas Area Rapid Transit (DART), the public transit agency for the Dallas Metropolitan area. Blue Fuels Group, L.P. is the current supplier of LNG to DART, El Paso Sun Metro, Houston MetropolitanTransit, Greater Austin Transit Authority, H-E-B Grocers of Houston, Texas A & M University and Southwest Research Institute in San Antonio/

Lone Star Energy Company's (LSEC), TXU Gas Company - Alternative Fuels Division, was selected for this contract due to the variety of services it provides in the natural gas vehicle fuel market (refer to Attachment A for more information). LSEC has been a leader in the building of fueling facilities for the last 10 years and has completed the design and construction of over 25 CNG stations, 3 LNG stations and 1 LCNG station. LSEC is a CNG retailer and designs and builds CNG fueling facilities. LSEC is also a LNG retailer, transports LNG, designs/builds LNG and LCNG fueling facilities and operates a vehicle conversion center, TranStar Technologies.

LSEC is known in the industry for its expertise in developing and building liquefied and compressed natural gas (LCNG) fueling facilities. The company possesses the experience and expertise necessary to develop documentation of the review and planning process for the developing and siting of LCNG facilities. In addition, North Star Inc. (NorthStar), a sub consultant to LSEC on this *Advance Fueling Infrastructure Project,* is also an experienced and respected designer and builder of LNG/LCNG facilities. North Star has recently completed a facility in California and has projects under construction in Arizona (refer to attachment B for more information).

The Task 1A report details the steps involved in the planning, review and permitting processes of building a station. Areas where difficulties typically arise are stated in order to inform the applicant of the process and facilitate the successful building of future fueling facilities. A summary of the planning, review and permitting requirements encountered in the construction of recent LSEC and North Star projects is included in this report to provide a real-world illustration of the facility development process.

Natural Gas Vehicle Fuel Background Statement

One of the critical barriers to advancing natural gas as a transportation fuel is the development of adequate networks of fueling facilities. The building of one fueling site requires a substantial capital investment ranging from $200,000 to $3,000,000. Improving the economic viability of LNG or CNG for transportation use requires that the cost of building new fueling facilities be minimized. One method of doing this is to reduce the high incremental costs associated with unanticipated delays in the planning, review, permitting and final acceptance phases of such a construction project. The permit process can be very slow due to the administrators and regulating agencies lack of experience with the development of LNG/LCNG fueling facilities combined with a lack of documentation of planning, zoning and code enforcement practices for LNG/LCNG facilities. Any additional delays and associated costs incurred by the facility builder dramatically impact the project economics. The facility has to be complete and operational typically in advance of the vehicle(s) delivery and any delays results in lost sales and extended capital outlay with limited incoming revenues.

The natural gas industry recognizes the need to establish a standard approach to obtaining the necessary approvals for fueling facility development. Compressed natural gas is increasingly being used as a vehicle fuel around the world. In the United States it is gaining acceptance due to its economic, energy security and emissions benefits.

Natural gas has been liquefied for several decades for storage in peak shaving facilities, to transport stranded gas and to remove impurities, particularly nitrogen. Recently with advances in engine technology, LNG has become a serious alternative vehicle fuel particularly for heavy-duty vehicle applications.

In order to increase the economic viability of the fueling site, both CNG and LNG can be dispensed from the same facility. Vaporizing the LNG at high pressure produces the CNG with less energy required than compressing the natural gas from the pipeline. At sites where LNG fueling is required it is typically more economical to add the LCNG capability than to install a CNG compressor. By expanding the universe of vehicles that can refuel at these facilities to include heavy-duty vehicles, the station economics can be improved.

Because of the increase in fueling capabilities and the inherent cost savings, more facilities are building built to dispense both CNG and LNG. The following is a list of U.S. LNG and LCNG facilities (by State and year started as of February 2000) developed and fleets deployed that will fuel at those facilities:

LNG Project	Location	Year Started	Number of Vehicles	Type of Vehicles	LCNG Capability
Arnett	Phoenix AZ		15 LNG	Paratransit	No
ATC-Vancom	Phoenix AZ		39 LNG	30' Transit	No
Phoenix Transit	Phoenix AZ	1997	191 LNG	40' Transit	Yes
			10 CNG	LUV's	
Grand Canyon National Park	Grand Canyon AZ	1998	7 LNG	Shuttle Bus	Pending
			5 CNG	40' Transit	
Tempe Transit	Tempe AZ	1998	50 LNG	30' Transit	No
Empire Power Systems	Phoenix AZ	2000	50 LNG	Class 8 Tractors	Pending
	Mesa AZ	2000	50 LNG	Class 8 Tractors	
LAX Airport	Los Angeles CA	1995	43 LNG	40' Transit	Pending
		2000	12 LNG	40' Transit	
Taormina Ind.	Anaheim CA	1996	28 LNG	Refuse Haulers	No
United Parcel Service	Ontario CA	1997	4 LNG	Package Vans	Yes
			42 CNG	Package Vans	
OmniTrans			20 CNG	Paratransit	
Trucking Unlimited			2 LNG	Class 8 Tractors	
Jack B. Kelley			3 LNG	Class 8 Tractors	
Raley's	Sacramento CA	1997	8 LNG	Class 8 Tractors	No
			2 LNG	Yard Goats	
City of Bakersfield	Bakersfield CA		6 LNG	Refuse Haulers	Yes
			2 CNG	Sweepers	
			30 CNG	LUV's	
Harris Ranch Feeding Company	Coalinga CA	1999	12 LNG	Class 8 Tractors	No
Safeway / Vons	Santa Fe Springs CA	1999	30 LNG	Class 8 Tractors	No
City of San Diego Environmental Services	San Diego CA	2000	54 LNG	Refuse Haulers	No

Idaho National Engineering Lab	Idaho Falls ID	1994	7 LNG	Motor Coaches	Yes
			126 LNG & CNG	Pickups & LUV's	
Greater Austin Transportation	Austin TX	1992	28 LNG	25' Transit	No
Houston Metro	Houston TX	1992	5 LNG	40' Transit	Yes
			5 LCNG	40' Transit	
Sun Metro	El Paso TX	1995	35 LNG	40' Transit	Yes
			20 CNG	40' Transit	
			30 LNG	25' Transit	
			20 LNG	Paratransit	
			25 CNG	Trolley	
			28 LNG & CNG	LUV's & Support	
Dallas Area Rapid Transit	Dallas TX	1997	140 LNG	40' Transit	No
DFW Airport Area 1E	Dallas TX	1996	5 LCNG	Honda Civics	Yes
Total NGVs Fueling from either LNG or LCNG			1209		

LNG Production and Delivery

LNG is produced by reducing the temperature of natural gas to an approximate temperature of minus 260 degrees Fahrenheit. The majority of the LNG production facilities in the U.S. are peak shaving operations or gas processing operations where high levels of nitrogen and other heavier hydrocarbons are removed from the gas stream. These facilities are typically located in unpopulated areas.

LNG is typically delivered to the site in 10,000-gallon cryogenic transports. The fuel is either pump offloaded or more commonly the fuel is pressure transferred into the fueling station storage vessel. Some stations are equipped with pumps to offload the LNG transport, others use the dispensing pumps for offloading and some transports are equipped with pumps.

LNG is delivered into a LNG vehicle storage tank by means of a LNG fueling pump. The pump is usually a multistage centrifugal pump installed in a vacuum jacketed sump commonly referred to as a dewar. The fuel is delivered in liquid form at up to 40 to 50 gpm with the delivery pressure limited to 90% of the relief valve set point of the vehicle tank, which is

typically 235 psig. The vehicle is inferred to be full when the LNG delivery rate decreases to a preset point, typically 5 to 7 gpm.

CNG Production and Delivery

The typical CNG station is located in near proximity to an existing natural gas distribution main. The station consists of an inlet gas meter valve train, natural gas compressor (either gas engine drive or electric drive), CNG storage vessels, priority and sequence control valves, CNG dispenser, controller and optional card reader for access control and billing. The natural gas is received from the distribution main at line pressure, which is typically available up to 20 psig but can range up to 800 psig.

The higher the minimum available gas main pressure the less compressor horse power is required of the natural gas compressor to elevate the inlet gas pressure to the storage pressure, of up to 5,000 psig. The minimum pressure available from the gas main must be confirmed to assure that the compressor is properly sized. The gas is stored in high-pressure vessels and the pressure differential between the storage vessels and the vehicle is used to allow the gas to free flow into the vehicle. The CNG flow is stopped when the maximum allowable vehicle pressure is reached. The gas pressure is measured at the dispensing hose and when the temperature compensated correct fill pressure is reached, the gas flow authorization valve is closed. The total fill pressure is not to exceed 125% of the fuel system rated pressure (i.e., 3,750-psig for a 3,000 psig rated vehicle system) and the upper limit pressure target is based on the ambient temperature and automatically controlled so that as the gas cools, the vehicle tank pressure will return to the correct operating pressure.

LCNG Production and Delivery

The LNG is delivered to the main LNG storage vessel as described above. The LNG liquid is pumped to the desired LCNG storage pressure (up to 5,000 psig) and vaporized by adding heat. The heat source can be ambient vaporizers or a boiler assisted glycol heat exchanger. The gas is warmed to approximately 20 degrees below the ambient temperature. The pump injection unit or a high-pressure wick-type odorizer adds Mercaptan to the gas prior to delivery to the CNG storage vessel(s). The LCNG is then stored and dispensed the same as the CNG systems described above.

Task 1A – Siting of LCNG Fueling Facilities

Executive Summary

Inherent Features of LCNG Systems

- Lower Horsepower – The work performed by an LCNG pump to compress liquid natural gas is a fraction of the work required to compress natural gas vapors. For example, a 3-gpm LCNG pump produces CNG at a rate of 250 scfm using a 25 horsepower electric motor compared to approximately 150 hp required to drive a compressor with a 20 psi inlet pressure and a comparable flow rate. Lower horsepower requirements mean lower operating costs.
- Consistent Fuel Purity – LNG as delivered to the station is normally of higher and more consistent fuel purity. As a result, CNG produced from LNG shares these fuel composition benefits. Natural gas vehicles can then be tuned to run with improved fuel efficiency and reduced emissions.
- Lower Gas Temperatures – CNG produced from LNG is approximately 20°F cooler than ambient temperatures. This lower gas temperature helps preclude the phenomenon of compression heating during CNG vehicle fueling. On hot days, this allows CNG vehicle tanks to be more completely filled.

Task 1A – Siting of LCNG Fueling Facilities

Request Statement

"One of the critical barriers to advancing natural gas as a transportation fuel is the development of adequate networks of fueling stations. Improving the market viability of liquefied natural gas (LNG) requires that such costs as those associated with the building of new fueling facilities be minimized. Currently, high incremental costs are associated with unanticipated delays in the planning and permitting phase of a project and other additional costs incurred as a result. Local administrators and regulating agencies lack experience with these types of projects. Moreover, the lack of information regarding planning, zoning and code enforcement practices prevent their making informed decisions in a timely and consistent manner.

There is a great deal of interest by the natural gas industry to establish appropriate and necessary planning documents for use by fire marshals and environmental and building permitting agencies. Consequently, it is important that the current review and planning process for siting of new liquefied/compressed natural gas (LCNG) fueling stations be documented. Hurdles and constraints should be clearly detailed so that specific improvements on the process can be addressed. A summary of the planning, permitting and agency requirements that were encountered in the construction of the Dallas-Fort Worth Airport LCNG Project will be included as a part of the interim report".

Project Objective

To improve the market viability of LNG/LCNG by minimizing costs such as those associated with the planning, permitting and review of new fueling facilities. The Task 1A report will:

- Document the process of obtaining the necessary permits and approvals;
- Detail the planning, siting and permitting processes for recent LCNG projects; and
- Identify existing hurdles and constraints in the siting and permitting processes with recommendations for improvements.

Equipment Description

LNG/LCNG Components Description

A typical LNG/LCNG fueling system consists of a LNG offload assembly, LNG storage vessel(s), LNG fueling pump(s), LNG saturation coil, LCNG high pressure pump(s), LCNG high pressure vaporizer(s), LCNG odorizer(s), LCNG storage vessel(s), LCNG Priority/Sequence Valve Assembly, LCNG dispenser(s), and LNG dispenser(s).

> *LNG Offload Assembly* – The offload assembly consists of the brass CGA fitting for a liquid and vent hose connection to the delivery transport, manual isolation valves, check valves and piping interconnect to the main LNG storage vessel(s). Some stations are equipped with offload pumps or can utilize the dispensing pumps to offload a transport. Some LNG transports are equipped with offload pumps and stations without offload pumps require that the LNG be offloaded by pressure transfer.

> *LNG Storage Vessel* – A vacuum-insulated pressure vessel ranging in capacity from 6,000 to 30,000 gallons. Tank maximum allowable working pressures are normally 250 psig or lower, with product stored at 50-120 psig. The pressure vessels are built and certified to ASME Section VIII Division 1 Standards. Vessels are either horizontal or vertical in configuration and typically consist of 9% nickel steel or 304SS inner and carbon steel outer, using double wall construction with super insulation under high vacuum.

> *LNG Fueling Pump* – A small centrifugal pump is used to draw LNG from the storage tank and transfer it to the vehicle tank(s). The latest technology used involves submerging a single or multistage centrifugal pump in a vacuum-insulated sump, allowing for on-demand LNG fueling.

LNG Saturation Coil – An ambient heat exchanger is typically installed so that the saturation pressure of the liquid can be raised to meet the pressure required of the vehicle engine. The LNG fueling pumps are typically used to circulate LNG through the ambient heat exchanger until the desired set point is reached.

LCNG High Pressure Pump - A positive-displacement reciprocating pump capable of generating high discharge pressures. LNG is drawn from the storage tank into the pump and discharged, as a liquid, at rates of 1 to 4 gpm and pressures of 4000-6000 psig. These rates produce gas flows of 85 to 320 scfm.

LCNG High Pressure Vaporizer - With high pressure liquid supplied from the LCNG pump, an ambient air heat exchanger or glycol heat exchanger with a gas fired boiler vaporizes and superheats the product to temperatures just below ambient.

CNG Odorizer - CNG must be odorized when used as a vehicle fuel. Since LNG is not available with odorant, Mercaptan must be added. The device is either a very small high-pressure direct injection system or a high-pressure wick type odorizer.

CNG Storage Vessel - Nearly all CNG stations use some form of gas storage either to augment vehicle fill rates, allow for a buffer volume between LCNG pump cycles or to minimize CNG compressor start/stops. Vessels are rated for up to 5000 psig and are either spherical or cylindrical in design and constructed of carbon steel. Spherical tanks typically range in size from 40 to 60 inches in diameter, and cylindrical tanks typically range from DOT 3A bottles to 20-inch diameter by 20 feet in length. CNG storage is commonly set up as a cascade, which means that a portion of the storage tanks are designated as high, medium, and low pressure banks.

Priority/Sequence Valve Assembly – The priority automatic control valves are used to direct the flow of gas from the compressor or heat exchanger to the appropriate CNG storage vessel(s) or directly to the vehicle fuel tank(s). The cascaded storage vessels are filled from the highest-pressure bank to the lowest pressure bank. The sequence valves control the flow from the storage vessels into the vehicle. The vehicle is filled beginning from the lowest pressure storage vessels up to the highest-pressure storage vessels and then directly filled from the compressor or heat exchanger if needed.

CNG Dispenser - Commercially available CNG dispensers are used at LCNG facilities. The dispensers can range from a simple single hose fill post to two hose cabinets with a card reader in the dispenser similar to modern gasoline dispensers. The gas is typically measured by a Coriolis effect mass flow meter. Many are equipped with automatic control valves to sequentially draw gas from cascaded CNG storage tanks.

LNG Dispenser - As of this writing, at least five different LNG dispensing systems are available from as many manufacturers. The assembly consists of a control valve assembly, volumetric meter or Coriolis mass flow meter and cool down recirculation capability. The dispensers are equipped with various authorization and user interface controls ranging from simplistic one button start to liquid crystal displays that provide instructions and information to the user.

Controller - As with the LNG dispensing systems, each station packager offers a unique control system. All use commercially available Programmable Logic Controllers (PLCs) with proprietary programs. The LNG dispenser panel is typically located adjacent to the LNG storage vessel. The CNG dispensing, LNG dispensing and LCNG production are controlled by a PLC panel located in an enclosure 15 - 75 feet from the classified area.

Card Reader – Some systems use a card reader to control access to the LNG or CNG fueling. The fueling information is gathered electronically from the card for billing or fleet management purposes.

Approach/Organization

Permitting Process

The permitting process for a LNG / LCNG facility is no different than any other construction project, in that a building permit must typically be obtained from the local governing authority. The added requirement of obtaining the approval of the local Fire Department and State Agency is required in some cases, since the permit is for a specialized vehicle fueling system. The process includes the following:

- Pre-design planning at the job site to consider
  - Tank Selection:
    - ✓ Above Ground vs. Under Ground
    - ✓ Vertical Vs Horizontal
    - ✓ 13,000-gallon minimum to accept full 10,000-gallon transport loads
    - ✓ Conditioning tank(s) required
    - ✓ Design Pressure(s) required
    - ✓ Total volume of storage required
    - ✓ Total number of dispensing hoses

- Siting:
  - ✓ Property Line setbacks
  - ✓ Clearance to adjacent structures
  - ✓ Flame propagation studies
  - ✓ Overhead power lines
  - ✓ Traffic Patterns
  - ✓ Access for transport to offload
  - ✓ Location of storage relative to dispensing area
  - ✓ Availability of electric and telephone service

● Building Trade Permits for civil, mechanical, and electrical work will also typically be required. The list of documents required for submittal to obtain the building and trade permits will typically include: site plans showing distance to property lines, proximity to buildings, traffic patterns, landscaping, utilities, etc. Equipment specific items to be shown on site plans or other drawings include:

- LNG storage vessel(s) size, location and specifications
- LNG spill containment calculations, type of construction and area
- LNG and LCNG pump capacity(s)
- LNG dispenser(s) location and specifications
- LCNG vaporization equipment location and specifications
- CNG storage vessel(s) size, locations and specifications
- CNG dispenser(s) location and specifications
- System schematic (process & instrumentation diagram) complete with pressure ratings for pipe and equipment
- Seismic calculations for structures and foundations (only required for Seismic areas)
- Electrical schematic
- Fire protection equipment
- Methane detection devices and system operational sequence
- Emergency shut down (ESD) devices
- Life safety features

● Trade permits are typically required for each area of the work. Most municipalities require that a subcontractor must be licensed for the type of work performed and a building permit for the project must be obtained before a trade permit will be issued.

● The local authorities may require an environmental review. EPA and State environmental guidelines must be met. Local authorities should be contacted to determine the requirements; referral to County or State Agencies may be necessary. Environmental reviews have not typically been a problem in permitting LNG or CNG fueling facilities but the proper department reviews must be obtained.

- An operating permit or Certificate of Occupancy may be required by the local authorities prior to operation of the facility. The governing authority provides the CO or operating permit after all code inspections are complete and approved.

- Approval of State Agency, i.e. Railroad Commission of Texas or California Pressure Vessel Division (OSHA), may be required.

- It is the responsibility of the applicant to assure that all permits, inspections and approvals are obtained.

Approach

Local administrators and regulating agencies typically lack previous experience with these types of projects and the best approach is to first personally visit the individual responsible for plan review at the local fire department. The building permit individuals will typically defer judgment to the fire department regarding the fueling system. Be prepared to offer a tactful education in LNG properties, CNG properties and LCNG equipment. Also document all information and directions received complete with the name and title of individual providing the information, for future reference if needed. It is very important to determine if you are reviewing the project with appropriate individual. Each local government has accepted either the Uniform Fire Code or the NFPA Standards or variations thereof to be the governing regulation. In addition, the project must incorporate the requirements of any local codes into the design.

It cannot be overemphasized that the better the presentation of the information regarding planning, zoning, life safety and code requirements, the more likely that code officials will provide their decisions in a timely and consistent manner. As the authority having jurisdiction, the fire department may chose to follow any or all of the NFPA Standard recommendations. The fire department may go beyond the scope of the standards, before feeling at ease with the station.

The compilation of a document that would educate and inform code officials and design engineers on appropriate and necessary planning documents for use by Fire Marshals, Environmental and Building Permit agencies would be beneficial. Consequently, it is important that the current review and planning process for siting of new LCNG fueling stations should be documented.

As more natural gas fueling facilities are constructed and operated it will become easier and more timely to obtain the necessary approval of governing authorities. As more stations are designed, permitted and constructed, the costs associated with the building of new fueling facilities should be reduced. The high incremental costs associated with unanticipated delays in the planning and permitting phase of a project will be reduced as code officials and design engineers become more familiar with the LNG vehicle fueling systems. The hardware costs of these facilities will also be reduced as the competition for equipment supply is increased and the efficiency of the designs is improved.

Hurdles and Constraints

Lack of Standard Regulations

Until the adoption of NFPA 57 in 1996, the only code for LNG storage or refueling stations was NFPA 59A, which was written for large storage facilities used in peak shaving applications. Many of the requirements in NFPA 59A are not needed for the greatly reduced storage volumes associated with LNG vehicle fueling systems. Even though NFPA 57 is more specifically designed to address the smaller scale storage associated with LNG vehicle fueling facilities, there are still unfamiliar areas that concern officials and therefore, are likely to slow down the permitting process.

Amount of Gas Stored at the Site

Using LNG requires larger amounts of gas storage on-site compared to CNG facilities. A minimum storage vessel size of 13,000 LNG gallons is needed to allow for full 10,000-gallon transport loads to be delivered. The difficulty arises in locating the storage vessels on sites with limited area due to building and property line setback requirements.

Some fire department officials have required vapor dispersion models to consider a vapor cloud ignition in case of a major spill of LNG, due to the LNG vaporization rate of 600 to 1. For example, 1 cubic foot of LNG if released will rapidly produce 600 cubic feet of natural gas. The gas cloud will hug the ground until the vapor reaches a temperature of minus 140 degrees F.

Odorized Gas

LNG is a colorless, odorless, combustible gas that is typically 98% plus methane and industry standards do not require odorant to be added, as with pipeline natural gas. The LNG in liquid form is a challenge to odorize because at the low temperature the odorant has a tendency to settle out of the liquid. Even if the LNG is odorized the greater challenge is to have the odorant attach to the gas vapor when the LNG is vaporized. The LNG stations and LNG vehicles therefore have methane detection systems to alert operators that a methane leak is present.

Cool Down Time

The time required to cool down and bring the LCNG system on line can be up to 20 minutes, particularly when fueling is intermittent. The time to bring the LCNG system online must be reduced to no more that a few minutes, to assure that a vehicle can be completely filled directly from the heat exchanger when the CNG storage is depleted.

Venting

Heat gain into the main LNG storage tank must be minimized. Frequent starting and stopping of the LCNG system, to replenish the CNG storage, can increase the head pressure in the main storage tank to the point that the tank must be vented.

Fire Equipment

LNG fueling facilities are sometimes required to install expensive automatic fire suppression systems, either dry chemical or high-expansion foam. The emphasis should instead be on prevention of releases and rapid response to unexpected releases.

LNG/LCNG Projects

The following is a summary of the planning, permitting and agency requirements that were encountered in the construction of recent LNG/LCNG Projects at Dallas-Fort Worth International Airport, Harris Ranch Feeding Company, and Empire Caterpillar:

Dallas-Fort Worth International Airport
LNG/LCNG Station
American Airlines Maintenance Facility
DFW Airport, Area 1E

Project Description

The DFW Airport Board and American Airlines (AA) agreed to a two-year project, which began in September 1995, to test the feasibility of LNG in the airport service vehicles. American Airlines converted 5 bag tractors, 5 pick up trucks and the DFW Airport Board converted 2 pick up trucks and 2 buses to operate on LNG. The conversions were performed by TranStar Technologies, a division of Lone Star Energy Company.

A 6,000-gallon horizontal LNG tank and single hose LNG pump/dispenser module were mounted on an 8 ft. wide x 36 ft. long x 9.5.ft high steel skid by Drexel/Hydra Rig. Drexel/HydraRig is an equipment manufacturer located in Fort Worth, Texas. The module was installed in the parking lot area of the AA Maintenance Facility and fueled AA vehicles for the test period of 24 months.

A grant was obtained from the Gas Research Institute by HydraRig in 1996 to install a high pressure LCNG pump and glycol vaporizer loop to produce LCNG. LSEC provided and installed the CNG storage and dispensing portion of the system including the CNG storage vessel, CNG dispensing controls, CNG dispenser, card reader, gas fired boiler, odorizer and fuel island canopy. The LCNG system was placed into service in December 1996 and remains in service today. The lessons learned from LSEC's first LCNG fueling system are included in *Task 1B Features of User Friendly LCNG Facility*.

System Description

The original system consisted of a 6,000-gallon horizontal tank, manufactured by MVE, installed on a structural steel skid. The LNG dispensing panel, LNG fueling pump and fueling hoses were installed in an enclosure at the end of the storage tank. A roll up door was installed to secure the equipment when not in use. A separate enclosure was constructed 75 feet from the dispensing area to house the non-rated electrical equipment including the variable frequency drive for the LNG fueling pump and the PLC controller for the system.

The single stage centrifugal pump is capable of delivering 40 gpm of LNG at up to 150 psig. The unit is equipped with an ambient air saturation coil and two LNG fueling hoses. One hose is equipped with a high flow (50gpm) nozzle and the other is equipped with a low flow (10gpm) nozzle. Moog manufactured the nozzles and the 10-gpm nozzles were used to fill the 17-gallon tanks on the bag tractors. The results of the fueling nozzles and flow rates will be further discussed in Task 1B.

LCNG capabilities were added as a inlet gas for boiler is taken form LNG storage trail head pressure vapor development project with the Gas Research Institute. A high-pressure LCNG pump and a glycol heat exchanger were added in the existing enclosure at the LNG storage tank. The controller enclosure was enlarged to accommodate the gas-fired boiler and make up tank for the glycol loop. Inlet gas for boiler is taken from LNG storage tank head pressure vapor. The controls were modified to operate the LCNG equipment and CNG storage and dispensing operations. The LNG fueling pump (3hp, 3 phase, 120 hz, 460 v) is used to provide LNG to the LCNG high-pressure pump (25 hp, 3 phase, 60 hz, 460v) to ensure that the LCNG pump does not lose prime. A 25,000 scf, 60-inch spherical CNG storage vessel, high-pressure injection odorizer, priority/sequence valves, CNG dispenser, card reader and fuel island canopy were installed. The CNG vaporization rate of the system is approximately 300 scf per minute. The LCNG is currently providing CNG to the DFW Airport Board's fleet of vehicles and is also open to the public. The United States Postal Service utilizes this site and the total average CNG volume sold per month is approximately 2400 gge's.

Permitting Process

The DFW Airport Board is incorporated as a municipality and the Airport Board staff is the governing authority at DFW Airport. The departments are organized as a typical municipality. A review was required by the environmental department and a building permit had to be obtained from the permit section, for which project approval had to be obtained from the Fire Marshal. The timeline of events is as follows:

The first DFW/LNG Evaluation Project Meeting was held March 30, 1995 with the DFW Airport Board personnel, American Airlines personnel, Lone Star Energy Company and Drexel/HydraRig personnel.

On April 25, 1995 design review meeting was held at the LNG site to determine the siting requirements.

LNG Sales Contract and leases were signed in June, 1995.

Revised site plans and containment volume calculations were submitted on June 20,1995.

Vehicles were converted to dedicated LNG supply in August and September of 1995.

Electrical Inspection of the LNG system was conducted on September 26, 1995.

LNG Fueling system was ready for operation on October 17, 1995.

Final Inspection of the construction was completed on October 25,1995 for the Installation of a Temporary LNG Fueling System. The work was found to be satisfactory and in compliance with the codes and standards adopted under the DFW Construction and Fire Prevention Standards Resolution. Certificate of Occupancy was issued on October 27, 1995.

The Railroad Commission of Texas "Regulations" for LNG were not in affect at this time so RCT approval was not required for this project.

The installation of the LCNG system was started after the LNG fueling system was operational. A construction application for the LCNG addition was filed with the DFW Airport Development Department on August 15, 1996.

Environmental impact review was completed for the Permit Application No. 96-275 on September11, 1996. The review required that all coatings to be in compliance with the Texas Natural Resources Conservation Commission regulations and that Material Safety Data Sheets (MSDS) sheets for all paints and coatings were to be provided.

A meeting was held on October 09, 1996 to discuss TA# 96-275 American's 1E Addition of CNG to Existing LNG system. LSEC and Drexel/HydraRig personnel explained the proposed system to the DFW review personnel.

The application received a Structural Review, Building/Fire Review, Mechanical and Electrical Review. Approval was granted for the Concrete Construction and Underground Utilities only on October 9, 1996. Demolition began while additional details that were requested and changes to the electrical and mechanical drawings were under review. The pre-construction meeting was held on October 15, 1996. The Mechanical, Electrical and Building/Fire approvals were obtained on October 16, 1996.

Structural inspection approval was obtained on October 31, 1996.

Mechanical/Building inspection was performed on November 06, 1996.

Electrical Inspection was performed November 23, 1996.

A separate Certificate of Occupancy was not required because the addition of LCNG was an alteration to the existing LNG facility. The system was made operational on December 11, 1996.

DFW Project Photos
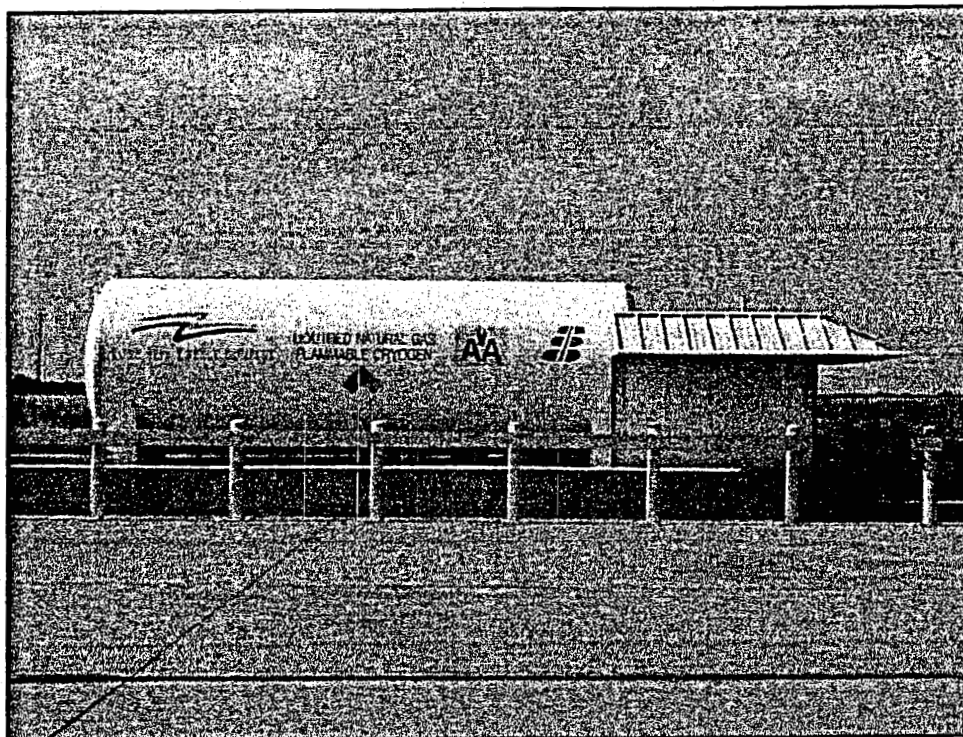
CNG MADE FROM LNG (DFW)

Harris Ranch
LNG Truck Fueling Station
Coalinga, California

Project Description

Harris Ranch is a large agri-business company specializing in the feeding, slaughter and packaging of beef cattle. Harris Ranch has distinguished itself as a provider of premium quality beef products, both fresh and cooked. Committed to improving the air quality, Harris decided in 1998 to purchase twelve class-8 trucks to replace existing diesel units. After selecting Caterpillar electronic dual-fuel engines and Freightliner chassis, Harris Ranch began the process to procure the refueling station.

NorthStar, Inc. of Evanston, Wyoming was selected to construct a LNG station at their feedlot under a turnkey design/build contract. The contract was awarded April 1,1999 and the first truck was fueled July 31, 1999.

System Description

A 16,400-gallon LNG storage tank from Process Engineering Incorporated in Plaistow, New Hampshire was used. Originally sized as a 13,000-gallon tank, the volume was increased in order to anticipate the forthcoming code requirements of California's OSHA Title 8. The particular requirement to be met is a minimum 10% ullage space. A working volume of 14,800 gallons thus gives the station operator more flexibility in scheduling LNG deliveries of 10,000 gallons.

The LNG storage tank feeds a centrifugal pump that is submerged in a vacuum jacketed dewar, which can be isolated from the storage tank. The dewar is mounted on a prefabricated skid complete with control valves, a meter run, a heat exchange coil, pneumatic controls, transmitters, and an electrical junction box.

The submerged pump is used to transfer fuel to the vehicles. An ACD model TC-34, 1x2x6 two stage; can transfer LNG at 30-40 gpm at 80-90 psi head pressure. The amount of pump head available is critical to overcome the pressure in the vehicle tank and initiate a single hose fill of the vehicle tanks.

The LNG delivered to the vehicle is measured by a Rosemount model 8800A vortex-shedding meter. In conjunction with a temperature probe, the metering system continuously corrects for product density variations and calculates mass flow.

The fan assisted ambient air heat exchanger is used to saturate the entire contents of the LNG tank after it has been refueled. In short, the saturation process adds heat to the product to raise the normal boiling point. The higher boiling point then provides the pressure in the vehicle tank whereby fuel is delivered to the engine. The Caterpillar dual fuel engine requires a minimum saturated pressure of 110 psig.

A second cryogenic pump was installed to assist in the offloading of a transport trailer. This Cryogenic Machinery model C-C pump has dimensions 1½ x 3 x 12, and transfers 200 gpm at 90-psi head.

Permitting Process

The site is not located within a municipality so the governing authority was Fresno County. A pre-construction meeting was held in Fresno, California, to acquaint county and other government officials with LNG as a vehicle fuel, the proposed fuel station equipment, and proposed safety systems. The requirement for an air quality permit from the San Joaquin Pollution Control District was waived. Due to the large amount of space available to site the equipment, fire detection and suppression equipment were not required by the Fire Department.

A set of plans was submitted to Public Works & Development Services, and a second set was submitted to the Building Department, both of the County of Fresno. Public Works & Development Services reviewed overall site considerations such as parking, traffic flow, water runoff, etc. The Building Department divided up plans to be reviewed by Zoning, Civil, Mechanical, Electrical, and Fire Department officials. All permits were received in June, 1999.

County building inspectors performed regular inspections. As an outcome of the final Fire Department inspection, local fire companies were invited to tour the station and become familiar with known hazards and existing safety systems.

Harris Ranch Project Photos
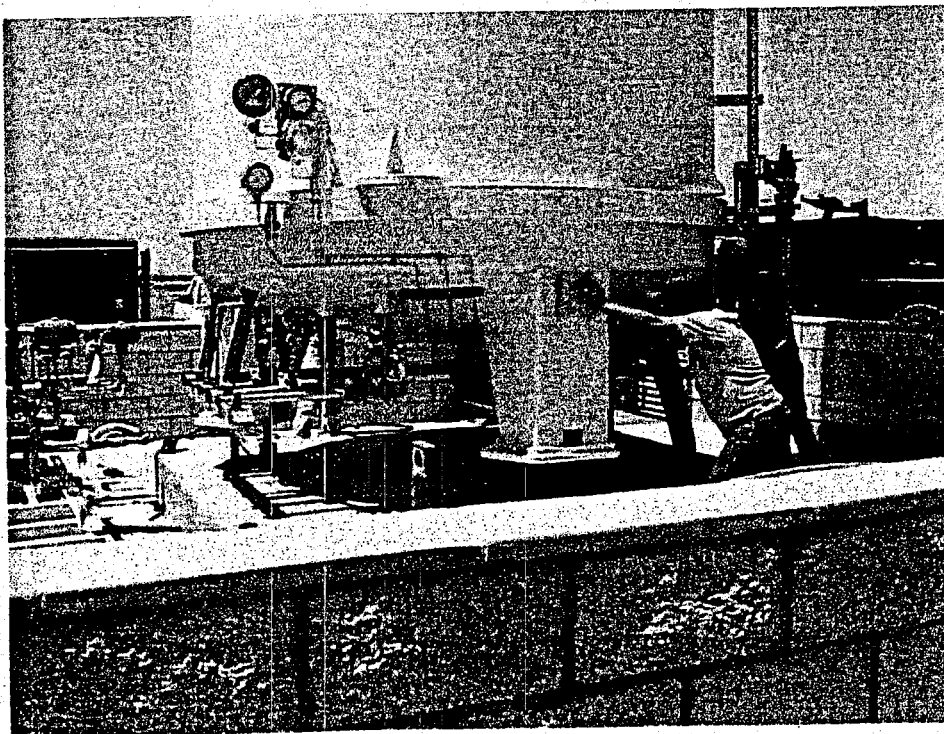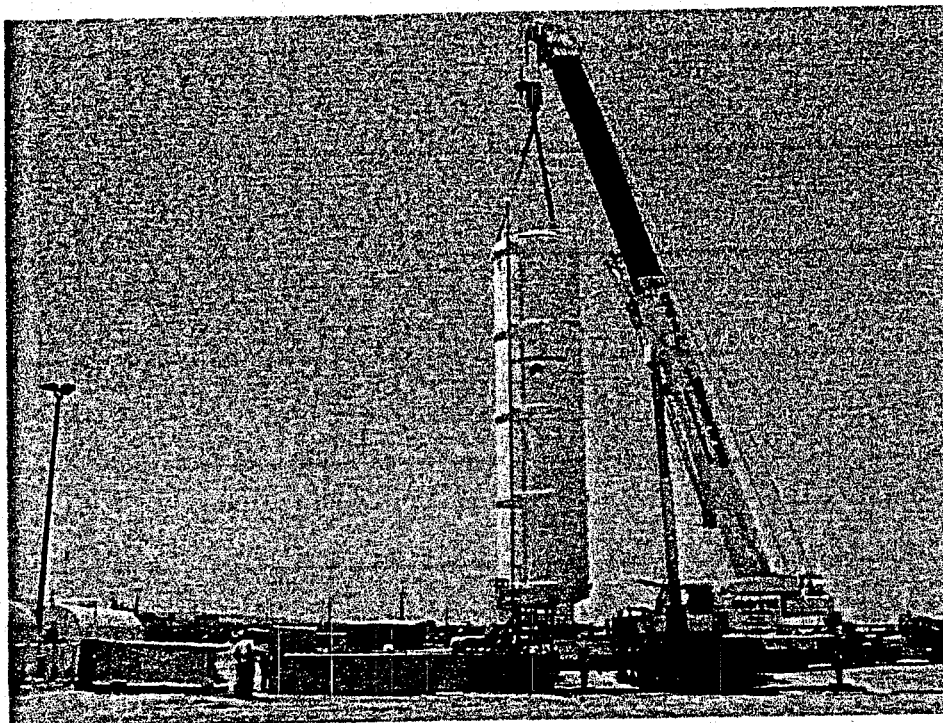
Implementation of Advanced LCNG Fueling Infrastructure in Texas along the I-35/NAFTA Clean Corridor Project

Empire Caterpillar
LNG Truck Fueling Station
Phoenix, Arizona

Project Description

Empire Power Systems (Empire PS) is the Arizona Dealer for Caterpillar engines and equipment. To combat the effect of diesel emissions in the Phoenix area and advance the implementation of Caterpillar electronic dual-fuel engines, Empire PS plans to make available in excess of 150 class-8 trucks. Trucks will be available on either a lease or purchase basis.

NorthStar, Inc. of Evanston, Wyoming was selected to provide two LNG fueling stations under turnkey design/build contracts. The first is located at 5164 W. Roosevelt in Phoenix, just off the intersection of Interstate 10 and 51st Avenue. The permitting process for the Phoenix site is described below. The second site is in Mesa, Arizona on Empire PS's property, just off the intersection of Highway 60 and Country Club Drive. Both stations will be operational in February 2000, and will be open for other LNG fleets on a card-lock basis.

System Description

The LNG equipment supplied is very similar to the Harris Ranch station as described above. The major difference is that the transport offload pump and the vehicle-fueling pump have been combined into one. The new 1.5x2.5x6 two-stage pump is a "ported out" version of the previous model. The submerged pump provides higher flows for transport offloading, as well as relatively higher discharge pressures for vehicle fueling.

Located adjacent to a card-lock conventional fuels terminal, the LNG station is in an excellent location for commercial fleets.

Empire Power Systems added LCNG capabilities.

Permitting Process

Acquiring permits for an LNG station from the City of Phoenix was rigorous and time consuming. Fortunately, the design team that was formed as a result of the Harris Ranch project was better prepared to generate the information required.

The City was contacted to determine what permits would be required. Prior to breaking ground, permits for:

Grading,
Dust (Maricopa County)
Right-of-way (driveways),
Landscaping,
Signage,
Fire Hydrant,
Building & Safety (Civil, Mechanical, Electrical), and
Fire Department had been secured.

To accomplish this, NorthStar prepared drawings, calculations, and reports as follows:
Pavement, grading and drainage drawing
Landscaping drawings
Equipment foundation drawing
Equipment layout drawing
Electrical power distribution drawings
Seismic and wind load calculations
Process and instrumentation diagram
Fire protection review
Fire protection drawing showing gas detection, flame detection, and safety systems

Several items from the Fire Department review augmented the recommendations of NFPA 59A. For example, in addition to the gas detection and fire detection devices being supported for 24 hours with a back up power supply, all alarm-annunciating devices were required to be able to operate for 24 hours as well.

The definition of "adequate water supply" is left to the local authority. A fire hydrant across the street was deemed insufficient, so a water line was branched off to a new hydrant within the property line.

Since the station was to be unmanned, an automatic telephone call out device was required in the event of an alarm or other operational problem. In the event of an alarm, the auto-dialer informs an alarm monitoring company, which in turn notifies the local 911 network.

Empire Phoenix Project Photos
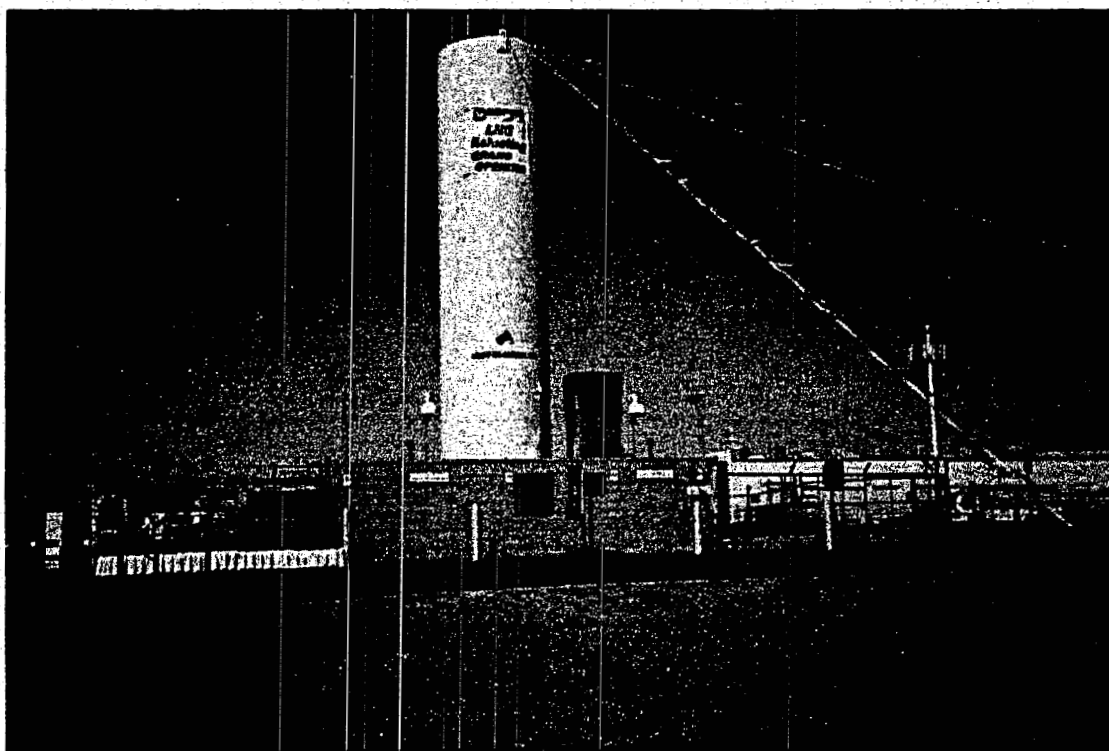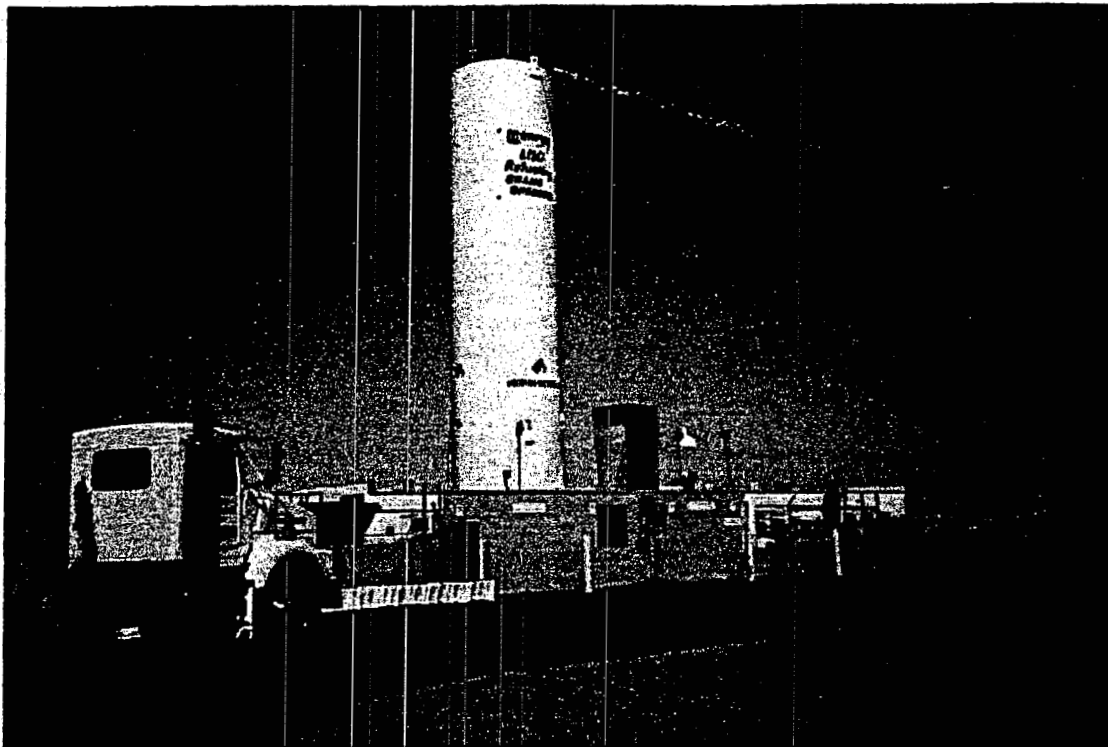
Implementation of Advanced LCNG Fueling Infrastructure in Texas along the I-35/NAFTA Clean Corridor Project

Contract Number DE-AC02-99CH11012– DOE Chicago Operations
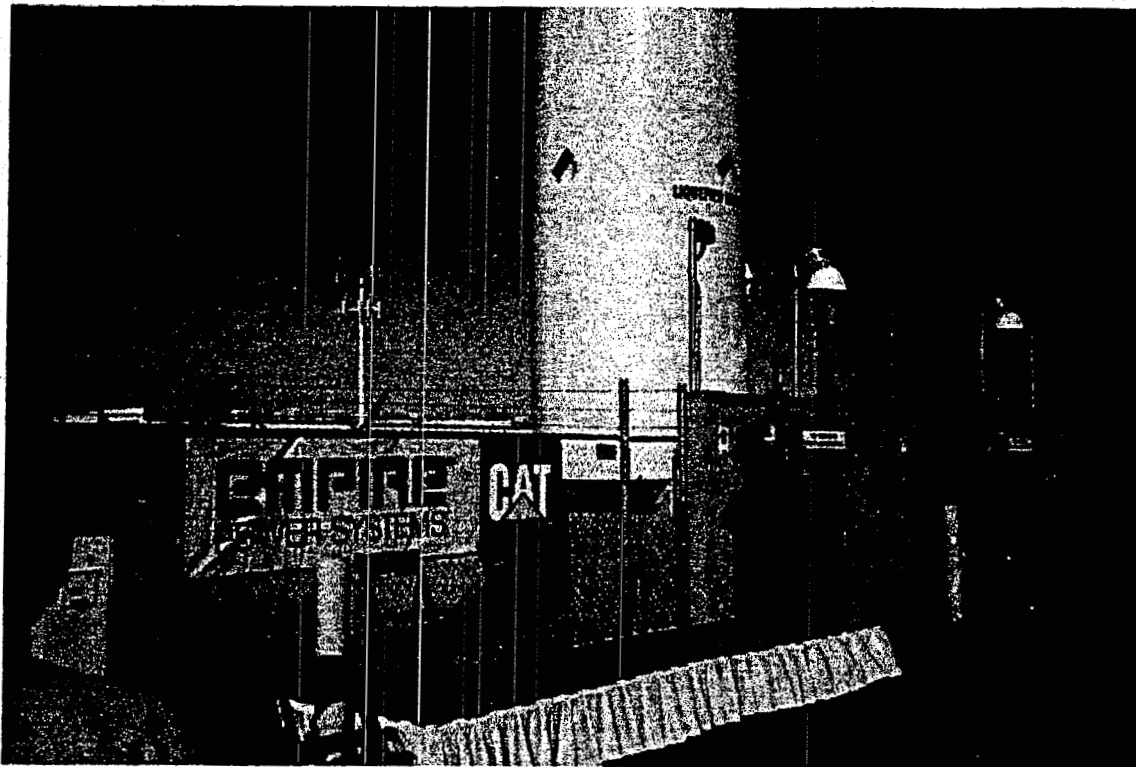
Closing Statement Task 1A

Education of the local authorities in regards to LNG and LCNG was necessary in every case. Knowledge base of projects is growing and NFPA standards now available have improved the permitting process. There have been no fatalities to date associated with natural gas as a vehicle fuel and no station accidents with large releases of natural gas so the comfort level is increasing. However, it can still be a challenge and time consuming to permit a facility in an area unfamiliar with LNG or LCNG. Environmental permitting and Fire Department reviews are still subject to interpretation. Hopefully, the siting and permitting process for the three LNG/LCNG projects as described in this report will improve the siting and permit process for future facilities.

Task 1B – Features of User-friendly LCNG Facility

Baseline LNG and CNG Level Data at DFW Airport

Date	LNG Tank Level							LNG Added to LNG Tank					CNG Sales per month	
	LNG Head Pres (psi)	LNG Tank Vented?	Estimated LNG Saturation Pressure	LNG Recorded Inches	LNG Recorded Inches	LNG In Tank Inventory (lbs)	Change in LNG Tank Inventory due to Venting (lbs)	Fuel Source	LNG Delivered per ship ticket (lbs)	LNG Delivered per ship ticket (Gallons)	LNG Dispensed to Transport (Gallons)	LNG Dispensed to Transport (lbs)	CNG Dispensed (GGE)	CNG Dispensed (lbs)
02/01/00	120			30.0	23.0	15183								
02/04/00	160	yes	140	27.0	20.0	13064								
02/04/00	125		125	26.5	19.5	12685	380							
02/07/00	160	yes	140	24.5	17.5	11142								
02/07/00	125		125	24.0	17.0	10713	429							
02/09/00	175	yes	150	22.0	15.0	9188								
02/09/00	100		100	21.5	14.5	8672	516							
02/09/00	75			34.0	27.0			Amoco	12372	3545				
02/10/00	75			35.5	28.5									
02/16/00	150	yes	125	31.0	24.0	15834								
02/16/00	100		100	30.5	23.5	15508	326							
02/20/00	160	yes	140	26.0	19.0	12321								
02/20/00	100		100	25.5	18.5	11828	493							
02/21/00				25.0	18.0						175	611		
02/24/00	160	yes	145	21.5	14.5	8818								
02/24/00	100		100	21.0	14.0	8305	513							
02/28/00	165	yes	150	17.5	10.5	5679								
02/28/00	100		100	17.0	10.0	5169	510							
02/29/00	110			15.0	8.0									
02/29/00	50		.	38.0	31.0			Amoco	14720	4218			1945	11009
03/06/00											180	628		
03/07/00	100			31.5	24.5									
03/10/00	145	yes	125	28.0	21.0	13765								
03/10/00	100		100	27.5	20.5	13390	376							
03/13/00				25.5	18.5									
03/15/00	160	yes	150	24.0	17.0	10816								
03/15/00	100		100	23.0	16.0	9852	965							
03/20/00	160	yes	140	20.0	13.0	7596						160	558		
03/20/00	100		100	18.5	11.5	6352	1244							
03/22/00	125			15.0	8.0									
03/22/00	45			32.0	25.0			Pioneer	9381	2688				
03/24/00	55			35.0	28.0									
03/30/00	100			28.5	21.5	14143							1847	10453
Total						1050			38473	10451	515		3792	
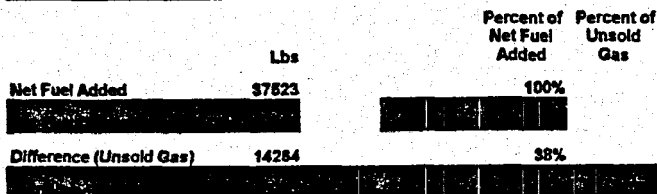
	Lbs	Percent of Net Fuel Added	Percent of Unsold Gas
Net Fuel Added	37523	100%	
Difference (Unsold Gas)	14284	38%	

The data from February and March 2000 represents baseline LNG and CNG delivery and sales information. It demonstrates that 36,473 pounds of LNG were delivered by tanker truck during the two-month period. From the beginning of the baseline period to the end of the period, the tank was drawn down an additional 1050 pounds. Thus, Net LNG Used is 37,523 pounds. Net Fuel Dispensed is also determined by adding two components. The first, LNG Dispensed to Transport Tractors is 1797 pounds and it used to fuel the LNG delivery transport tractors. The second component, CNG Dispensed describes LNG that has been compressed, flashed to gas, and odorized; 21,462 pounds of LNG were vaporized and sold as CNG. Net Fuel Dispensed is 23,260 pounds. Thus, Unsold Gas is a significant difference (14,264 pounds) between the Net LNG Used and Net Fuel Dispensed. This Unsold Gas makes up 38% of Net LNG Used. We estimate that the high pressure LNG pump and gas fired boiler started about 7 times each day during this fueling cycle.

One of the goals of this project was to reduce the amount of Unsold Gas. Unsold Gas is primarily made of two components: vented gas and gas used to fuel the glycol boiler for the vaporizer. The vented gas during the Baseline period is estimated to be about 5751 pounds, 40% of Unsold Gas. The reduction in the amount of vented gas is a prime focus of the Improvements Completed section. LNG delivery procedures, control system modification, and hardware additions were made to reduce the amount of vent gas.

Improvements Completed

CNG Production Control System – The Opto Controller was upgraded to the Windows NT version of Cyrano called Factory Floor. Factory Floor includes many enhancements including compatibility with Microsoft Office, a built in MMI (Man-Machine Interface) package and server package. A completely new Strategy was written to take advantage of all the sensors in the system. This resulted in more precise monitoring of shutdowns and system operation. A MMI was developed by Lone Star Energy Company for station technicians to use for troubleshooting. The MMI gives the technicians a Graphic display to represent station operation. Although it works well for onsite personnel, it requires special software for monitoring the system offsite.

In order to allow remote station monitoring without special software a Cyber node lite thin Internet server from Concur System Technology was attached to the controller. This allows transfer of information to be viewed on any computer with a web browser. The server can be set in a passive or active mode. In active mode the server transmits continually to the Internet. Anyone wishing to view the information could simply type the URL into the web browser. In passive mode a dial-up connection would have to be made to the web server. Once it is connected, the web browser can be started and the URL entered. The web server also allows control of system variables (CNG Start Pressure, LNG Pump Speed, etc.) and viewing of any system parameter.

To interface the system controller and the web server, special drivers were written by Parijat Controlware. These drivers were error prone and were replaced by drivers written by Concur Systems. These drivers allow the Cybernode to use the Tag names in the controller's strategy. Which speeds the time taken to design a web page. A set of web pages was designed from the MMI to allow access from any PC. The web pages are password protected to limit access to authorized persons.

For emergency callout a United Security Products AutoDialer was connected to an ESD output. This device allows up to four numbers to be called in the event of a shutdown. An E-mail will be generated by the web server during an abnormal condition.

Specific information on each of the devices is included in the appendix.

The CNG Production Sequence of Operation was revised as follows: Compressed Natural Gas (CNG) production begins when the CNG storage pressure drops below 4100 psig and the CNG Start/Stop switch is turned to Start. The cool-down process of the low pressure LNG (Liquid Natural Gas) pump (P-1) begins by the opening of the LNG Pump Suction Valve (V-3) and the LNG Recirculation Valve (V-5) to allow LNG to gravity feed into the LNG pump. After the LNG pump has cold soaked for three minutes and the LNG Temperature probe is lower than minus 180 degrees Fahrenheit the pump is turned on. The pump continues to run until the temperature reaches minus195 degrees Fahrenheit or less.

After the LNG pump cool-down process is complete, the LNG Re-circulation valve closes, the LCNG Re-circulation, Pump priming, and Suction valves are opened. LNG is pumped through the LCNG High pressure pump and back to the top of the LNG storage tank in order to cool the LCNG pump. The glycol boiler and pump is also brought to operating condition of 140 degrees during a seven minute timed process. After the cool-down time has expired the LCNG pump is turned on. After 60 seconds, the LCNG re-circulation valve is closed and pressurized LNG is diverted through the vaporizer, where it flashes to a gas. The gas is stored in the CNG pressure vessel. CNG production stops when the CNG storage pressure reaches 4900 psig.

CNG production can be stopped by depressing the Emergency Shutdown Button (ESD) or automatically by the control system. The controller monitors the current draw on the LCNG pump motor. If current drops below a user defined set point, the controller will stop the CNG production sequence and light the Loss of Prime light. Due to the unreliable nature of this shutdown, a pressure transducer was added to the system to monitor the output pressure of the LCNG high-pressure pump. This pressure is compared to the storage pressure as verification of pump output. LNG Pump temperature and CNG output temperature are also monitored for an increase in temperature. A fault condition on any of these will result in an interruption in CNG production and a call to the station technician.

The existing LCNG station at DFW Airport has not been retrofitted with the new double acting-reciprocating pump as stated in the original request. In order to meet the CNG fueling needs of DFW Airport's dedicated CNG vehicles, and due to recurring problems, the existing triplex mono-block LCNG pump provided by Hydra Rig was replaced in May of 1999 by three separate high pressure cold-ends manufactured by ACD. Each cold-end is a positive displacement piston and cylinder assembly and is adapted to the warm-end individually. A small plastic poppet, similar to a compressor valve, on each cylinder directs the high-pressure LNG to the heat exchanger. The separate configuration of the three cold-ends allows for the replacement and repair of one cold-end at a time. The upgrade was completed in May of 1999 prior to DFW receiving five dedicated CNG Honda Civics when reliability of the LCNG station became even more crucial to the DFW CNG program. The extended delivery time of the preferred double acting reciprocating low inlet pressure pump and the associated piping modifications, did not allow for the installation. Because the dedicated vehicles have been fueling exclusively at this site, the system has not been available for any further modifications which require the system to be off line for more than a couple of hours at a time.

Although the new three-piece pump has performed more reliably than the original triplex, it has not operated flawlessly. The cold ends are prone to poppet and piston failure. If the cold ends are allowed to heat to ambient temperature, the poppets have a tendency to leak. Also, if cold-ends are run even briefly without liquid, the piston seals and poppets will fail.

In order to increase the amount of storage available to the customer, Lone Star Energy Company installed a pressure regulator manifold on each CNG hose. This addition allowed the CNG system start and stop pressures to be raised to 4100 psig and 5000 psig, respectively. Each manifold consists of two regulators and two pressure gauges. Each regulator has the buffer pressure as its inlet pressure. One regulator is a low-flow adjustable self-venting regulator. Its discharge controls the outlet pressure of the second high-flow type regulator through a dome-load input port. See Attachment D for a schematic of the regulator system.

The addition of pressure regulators for each CNG hose at the valve panel helps assure that allowable vehicle fill pressure will not be exceeded. The regulator system on Hose 1, the 3000-psig hose, is set to 3500 psig maximum. The regulator system on Hose 2, the 3600-psig hose, is set to about 4100 psig maximum. The addition of the regulators allows the storage pressure to be increased so that the system can dispense more fuel (about 14 GGE) before the LCNG pump start pressure is reached. Previously, the LCNG pump started after only about 7 GGE was dispensed. The higher storage pressure allows most 3600 psig vehicles to be filled completely from the storage vessel. It also has the added benefit of decreasing the number of starts and stops and increasing run time after the LCNG pump is started.

In addition to equipment improvements, Lone Star Energy Company made fuel delivery process changes in Spring 2000 to minimize the necessity to vent the LNG tank. We began to order fuel from Pioneer's plant in Satanta, Kansas for almost weekly delivery to the DFW site. Previously, most of the deliveries were made less frequently and sourced from Amoco's Chocolate Bayou plant. Pioneer's LNG is typically about minus 255 degrees Fahrenheit at a saturation pressure of 5 psig. Amoco's LNG is minus 235 degrees Fahrenheit at a saturation pressure of about 30 psig. During the time these process changes were made, CNG sales were also increasing. See the updated fueling data on following page(s) for more details on the positive and negative impact of this change and all of the changes made.

Updated Fueling Data

Date	LNG Head Pres (psi)	LNG Tank Vented?	Estimated LNG Saturation Pressure	LNG Recorded Inches	LNG Recorded Inches	LNG in Tank Inventory (lbs)	Change in LNG Tank Inventory due to Venting (lbs)	Fuel Source	LNG Delivered per ship ticket (lbs)	LNG Delivered per ship ticket (Gallons)	LNG Dispensed to Transport (Gallons)	LNG Dispensed to Transport (lbs)	CNG Dispensed (GGE)	CNG Dispensed (lbs)
06/29/00	140		124	24.5	24.5	16173								
06/30/00	150			23.0	23.0									
06/30/00	75			33.0	33.0			Amoco	7853	2250	123	429		
07/05/00	140			26.5	26.5									
07/06/00	149			26.0	26.0									
07/07/00	160	yes	145	24.0	24.0	15850								
07/07/00	100		100	23.0	23.0	15193	657							
07/09/00	130			20.0	20.0									
07/10/00	150			19.0	19.0									
07/11/00	175	yes	155	16.5	16.5	10396								
07/11/00	110		110	16.0	16.0	9873	523							
07/12/00	125			14.5	14.5									
07/13/00	150			15.0	15.0									
07/13/00	60			32.0	32.0			Pioneer	12958	3713				
07/14/00											119	415		
07/17/00	50			28.5	28.5									
07/18/00	60			26.5	26.5									
07/19/00	65			23.5	23.5									
07/20/00	80			20.5	20.5						119	415		
07/21/00	85			19.5	19.5									
07/22/00	100			17.0	17.0									
07/24/00	110			16.0	16.0									
07/25/00	120			12.0	12.0									
07/26/00	130			9.5	9.5									
07/26/00	15			32.0	32.0			Pioneer	15388	4409	119	415		
07/31/00	60			25.5	25.5								3278	18554
08/01/00	75		55	23.5	23.5									
08/01/00	60			22.0	22.0									
08/01/00	45			33.0	33.0			Pioneer	6889	1968				
08/01/00	42		42	32.5	32.5									
08/03/00											130	454		
08/04/00	75			29.5	29.5									
08/08/00	140			24.0	24.0									
08/08/00	60			32.0	32.0			Amoco	7040	2017				
08/09/00	75			33.0	33.0									
08/10/00	105			31.5	31.5						125	436		
08/16/00	160			20.0	20.0						119	415		

Date	LNG Tank Level							LNG Added to LNG Tank					CNG Sales per month	
	LNG Head Pres (psi)	LNG Tank Vented?	Estimated LNG Saturation Pressure	LNG Recorded Inches	LNG Recorded Inches	LNG in Tank Inventory (lbs)	Change in LNG Tank Inventory due to Venting (lbs)	Fuel Source	LNG Delivered per ship ticket (lbs)	LNG Delivered per ship ticket (Gallons)	LNG Dispensed to Transport (Gallons)	LNG Dispensed to Transport (lbs)	CNG Dispensed (GGE)	CNG Dispensed (lbs)
08/17/00	175	yes	160	18.0	18.0	11648								
08/17/00	110		110	16.0	16.0	9873	1775				85	297		
08/17/00	40			32.0	32.0			Pioneer	11953	3425				
08/18/00	45			32.5	32.5									
08/21/00	50			29.0	29.0									
08/23/00	75			25.5	25.5						130	454		
08/24/00	80			23.0	23.0									
08/24/00	45			35.0	35.0			Williams	6720	1928				
08/25/00	70			32.0	32.0									
08/28/00	90			28.5	28.5									
08/31/00	120		100	21.0	21.0	13735							4508	25518
Total						2439			68781	19708	1069		7787	

	Lbs	Percent of Net Fuel Added	Percent of Unsold Gas
Net Fuel Added	71219	100%	
Difference (Unsold Gas)	23417		33%
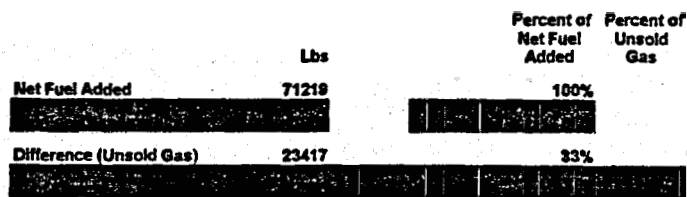
The Updated Fueling data can be used to make several observations and conclusions about the changes that were made during the Spring of 2000. Also affecting station operation is the fact that August's CNG fuels sales are double that of February 2000.

The increase has resulted in better operation for several reasons. First, the station uses more LNG, which reduces the LNG on-site inventory time between product delivery and dispensing to vehicles. The shortened inventory time means that the LNG gains less heat in the LNG storage before it is used resulting in less venting of the LNG storage tank. Heat is also gained in the LNG storage tank during the cool-down process. Thus, increased fuel sales result in less time between starts and stops. The system is generally colder during startup because less time has lapsed since the last run, which also results in reduced tank venting.

During June a regulator was added to each hose and the program changes were made that raised the CNG system start pressure to 4100 psi and the stop pressure to 5000 psi. Now the system starts after approximately 14 gge's are dispensed as compared to the 7 gge's that previously started the unit. This change allows more fuel to be dispensed before the pump is restarted and therefore the pump runs longer each time it operates and the number of starts is reduced. During the last month of this period, we estimate that the pump started only nine times each day to

dispense about 150 GGE/day. For the baseline period the estimate is seven times per day for about 65 GGE/day. Because the pump is started fewer times each day, the pump is cooled down fewer times each day. Thus, less heat is required for pump cool-downs and less heat is added during pump cool-downs to the LNG tank. This change and the increase in fuel sales have practically eliminated the need for venting the LNG tank.

Lessons Learned from Existing LNG & LCNG Systems

Dispensing Systems - The largest LNG tank that could be installed on the bag tractors was a 17-gallon tank manufactured by MVE. The fast filling of small volume tanks had not been done commercially in the past and several problems were encountered. The 10 GPM Moog low flow nozzles did not perform satisfactorily. The tanks developed head pressure quickly when fueling and due to the low amount of fuel delivered the head pressure was not easily collapsed.

Filling of overpressure vehicles in a single hose fill at this site is a challenge due to the single stage pump having a differential head capability of only 90 psig. If a vessel to be fueled is at a higher pressure than the total pump discharge pressure, then the vehicle tank must be vented to start the liquid flow into the tank. If the vent line is left open on the vehicle during fueling, the liquid can freeze the nozzle to receptacle.

The vehicle vessel Pressure Relief Valve for the MVE tanks is set at 235 psig so the pump discharge pressure cannot exceed 210 psig

The existing LNG pump is not in a dewar. The pumps currently used in the design of LNG fueling stations are vertical multistage centrifugal units in a flooded dewar, which reduces the cool down time, and provide additional pressure lift

The LNG meter needs to properly cold soaked to eliminate two-phase flow through the meter.

LNG Hoses – The insulated hoses are very stiff and hard to handle especially when cold. The stainless steel braids on the exterior of the hose began to abraid and unravel because of contact with concrete and metal surfaces. Canvas covers were added to protect the exterior SS braid of the hoses. For additional hose flexibility we are now using insulated super-flex hoses in canvas covers without the outer SS braid. VJ hoses are still used at one site but will be expensive to repair if damaged from pull-aways.

Controls – Saturation bulbs are now used to directly read saturation pressure in the storage tank. Fuel temperature at the dispenser can also be used to verify saturation pressure dispensed into the vehicle.

LNG Nozzles - The results of the fueling nozzles and flow rates (40 to 50 gpm). Moog LNG nozzles are now manufactured by J.C. Carter.

LCNG Pressure switch was added at LCNG pump discharge in attempt to assure that the pump is operating.

High humidity often causes problems with ice formation on the nozzle seal faces, resulting in difficulty in attaching and removing the fitting. Ice formation can also cause leaks during fuel transfer. Safety protection for the user should include both freeze and splash protection.

This was the first time that the low flow Moog nozzle had been used and the first time that the 17-gallon LNG tanks had been used in a vehicle application.

Recommendations
Improvements Needed

Controls - The LCNG production sequence of operation is still limited in its ability to monitor the LCNG pump for fault conditions. The high pressure pump consists of three separate cold ends that are individually prone to loss of prime and vapor lock, which can result in higher temperature and vibration. A temperature sensor should be added to each cold end to detect overheating. The tri-plex pump should also be retrofitted with a vibration switch to shut off the pump if vibration is detected due to loss of fluid flow.

CNG dispensing is currently controlled by the Micro Monitor panel. Although the system works well most of the time, moving sequencing control to the Opto System Controller would allow precise monitoring and historic trending of the dispensing sequencing and flow rates through each CNG hose. Historic trending is important because it allows troubleshooting of customer-reported dispensing problems.

Dispenser systems - Improvements are needed in the operation of the LNG dispensing systems in order to improve the customer interface similar to facilities serving conventional fuels. Current CNG dispensers feature credit card access controls and dispenser technology that is now comparable to conventional fuel systems. LNG dispensing systems need to incorporate these user-friendly features. In addition, the information interface with the customer during the LNG fueling process must be improved. The current LNG systems do not adequately inform the operator if there is a problem during the fuel transfer, and how to respond.

Cool Down Process - One of the problems with the current LCNG systems is the cool down time required before LCNG production can begin. Some LNG/LCNG systems utilize the LNG transfer pump to ensure prime of the LCNG high-pressure pump. The cool down time is thus extended due to the additional steps required to cool down the two pumps, pipe, valves and fittings. Another problem with using the LNG transfer pump to supply the LCNG pump is that the LNG fueling and the LCNG production cannot be performed concurrently.

Centrifugal Pumps - Improvements need to be made to the control system to ensure the centrifugal pumps are primed properly prior to start up, and that safety shut downs are effective in stopping the pump prior to experiencing damage if the flow of LNG is stopped. Discharge pressure must be adequate to overcome vehicle tank pressure for single hose fills.

High Pressure LNG Pump - The most unreliable part of the LCNG system has proven to be the high-pressure LNG pump used to provide LCNG. If the pump is not properly cooled prior to start up the positive displacement pump can be damaged. Pump removal and repair can be expensive and time consuming. The sensitivity of the high pressure pump to liquid temperature affirms the need for the additional controls described in the controls portion of this section.

Nozzles - LNG liquid and vent nozzles need to be improved for ease of handling, reliability, and safety-protection. In comparison, CNG fueling nozzles have been standardized, are fairly reliable, are easy to operate and have a good safety record.

Odorization – Odorized LNG would eliminate the need for an odorant injection system for the LCNG. The need for methane detectors at the station and on the vehicles would also be less critical.

Cool Down Time - The time required to cool down and bring the LCNG system on line can be up to 20 minutes, particularly when fueling is intermittent. If the pumps are not properly cold soaked prior to operation the pumps will lose prime, and the pump seals could potentially be damaged. The time to bring the LCNG system online must be reduced to no more than a few minutes to ensure that a vehicle can be completely filled directly from the pump when the CNG storage is depleted.

Venting - Heat gain into the main LNG storage tank must be minimized. Frequent starting and stopping of the LCNG system to replenish the CNG storage can increase the head pressure in the main storage tank to the point that the tank must be vented.

Fire Equipment - LNG fueling facilities are sometimes required to install expensive automatic fire suppression systems, either dry chemical or high-expansion foam. The emphasis should instead be on prevention of releases and rapid response to unexpected releases.

Further recommendations as to how to make future LNG and LCNG fueling facilities more user-friendly, reliable and cost effective, include:

* The inherent feature of producing relatively cooler gas from LCNG systems is not being fully utilized. Future control systems could more carefully control gas temperatures such that CNG vehicles could be more completely filled without need of excess fueling pressure.

- Future LCNG pumping arrangements could consider submerging the LCNG pump in a liquid dewar, similar to current LNG centrifugal pumps. This could even further reduce pump start times and prolong service life.
- For LNG fueling, the pressure requirement of the vehicles with the highest engine operating pressure determines the saturation pressure at which the entire station must operate. A reliable method to vary the saturation pressure of delivered fuel needs to be developed.

Refer to *Task 1C LCNG Station Design Details for further details.*

Task 1C – L/CNG Station Design Details

Task 1C – L/CNG Station Design Details

Request Statement: "The proposed LCNG fueling station has unique features that provide for optimized costs, safety, convenience, flexibility and ease of operation. The existing LCNG systems utilize the LNG fueling pump to boost the inlet liquid pressure of the high pressure LCNG pump. The cryogenic industry uses elevated vertical tanks to boost the inlet pressure to high pressure pumps but elevated vertical tanks will not be suitable in most LCNG fueling applications. A newly developed double-acting reciprocating pump is now available and has been successfully tested with a horizontal tank feed in the liquefied atmospheric gas service. The "sub zero pump" can operate at much lower inlet pressures which will allow LNG to be dispensed and LCNG to be produced at the same time. The interim report will include technical details of the pump selection and installation along with an equipment layout of the station, metering, nozzle design, LCNG heat exchanger design, gas pressure Mercaptan injection system, temperature/pressure/flow data, and fueling control systems.

An improvement of this new LCNG station over existing LNG stations is the system's design for minimizing boil-off, improved overall energy efficiency, separating the LNG and LCNG fueling capabilities and cost effectiveness of the fueling operation. The development of these concepts will be further detailed in the interim report."

LNG Equipment Details

Skid - The LNG vessel and fueling system was assembled on an 8' wide x 36' long x 9.5' tall steel skid by Drexel/HydraRig. The assembly was designed to be moved on a standard drop deck trailer with a 48" tall (max.) x 36' long lower deck. Weight (empty) is approximately 42,000 pounds. The components consist of:

LNG Storage Vessel - The storage vessel is a 6,000 gallon nominal capacity horizontal 9% nickel inner vessel and a carbon steel outer double wall super insulated vacuum jacketed tank rated for 250 psi. Equipped with the following:

> Liquid level indicator
> Standard fill and vent connection
> Relief valves
> 90% trycock
> Pump suction connection
> Pump return connection
> Vapor return connection
> Valving to permit re-circulation of liquid back to storage tank or direct fill to the vehicle

LNG Supply Pump - The LNG supply for vehicle fueling is provided by a 30 gpm cryogenic single stage centrifugal transfer pump manufactured by ACD (see attachment E). The single stage centrifugal pump is 3hp, 3 phase, 120 hz, 460 v and capable of delivering 40 gpm of LNG at up to 150 psig. The pump design requires that the pump be flooded and cooled for about two and one half minutes prior to start.

Control system – the dispenser panel is rated Class I Division I Group D and is located in the equipment enclosure at the end of the LNG storage vessel. The display prompts the operator of the LNG system and displays LNG gallons dispensed. The PLC panel is not rated for the hazardous environment and is therefore installed in a separate enclosure approximately 75 feet from the LNG fueling. Alarm lights and the message display indicate pump operation.

LNG Metering – The LNG is metered by a Coriolis effect mass flow meter manufactured by Micro Motion Model number RFT 9712-1PNG and Sensor Serial Number 18691, Model No. _____. The pulses from the mass flow meter are converted to liquid gallons based on a factor of 3.53 pounds per gallon. The volume dispensed is shown in LNG gallons on the digital display at a rate of 100 pulses per pound.

Fuel hoses - Two cryogenic insulated hoses 12 feet long to transfer fuel to the vehicle were installed. One is equipped with the 10 gpm low flow Moog LNG nozzle to fuel the 17 gallon tanks that were installed on the bag tractors. The other hose is equipped with a 50 gpm Moog LNG nozzle to refill the larger vehicle vessels The hoses are 1 ¼ inches inside diameter and 2 ¾ inches outside diameter with a SS outer braid. A vent return hose from the vehicle to the storage vessel is provided to initiate fill of the vehicles at high pressure that the pump cannot overcome.

Saturation Coil - Ambient air saturation coil to automatically condition the storage tank to assure NPSH for the transfer pump and to raise the saturated pressure of the liquid LNG to meet the vehicle requirements. The saturation pressure is calculated by the PLC based on the temperature of the LNG.

Pipe, Valves and Fittings - Piping shall be of sufficient size to affect an efficient transfer of cryogenic fuel from the storage tank to the vehicle. The active piping is vacuum jacketed. All components on the main skid are explosion proof rated Class I, Division I, Group D.

> Control valves
> Modulating valves
> Pressure transmitters
> Temperature transmitters

LCNG Equipment Details

CNG Dispenser – Two hose CNG dispenser manufactured by Fueling Technologies Inc. includes two coriolis effect ABB K-Flow mass flow meters, Model K-40CNG, rated for 40 pounds of flow per minute. The dispenser is equipped with one Sherex 3000 psig nozzle and one Sherex 3600 psig nozzle. Digital display reads in CNG gge's based on 5.66 pounds of natural gas per gallon.

LNG High Pressure Pump – The high-pressure pump raises the Liquid Natural Gas to a pressure of 5000 psig maximum and the high-pressure liquid is then vaporized and flashed into gaseous form. The original pump was a triplex unit driven by a 25 hp, 3 phase, 460V motor. The 1750 RPM speed of the motor is reduced to about 475 RPM by a 3.688 reduction gear box. The shaft of the reduction box is attached to a warm end, which converts the rotational motion into reciprocating motion via crank-shaft and rod configuration. Originally this system was used to drive a Hydra-Rig designed triplex pump. The triplex pump is a single unit pump that consists of three positive displacement pistons that operate in separate cylinders bored into one block. The pistons are not staged; they work in parallel. Each compresses the liquid from inlet pressure up to 5000 psig. When one piston fails, the entire triplex assembly has to be taken out of service for repair or replacement. Due to recurring problems with this arrangement, the single-piece triplex pump was replaced with the three independent cold endes in May of 1999. **See the Improvements needed section for details.**

LNG Vaporizer – Glycol assisted heat exchanger rated for 5000 psig was installed in the equipment enclosure at the storage vessel. The existing enclosure for the non-rated LNG equipment was enlarged to accommodate a natural gas fired 315,000 Btu input boiler. The boiler is used to heat the glycol mixture to 140 degrees Fahrenheit, which is circulated through the LNG vaporizer. The boiler is supplied with gas from the top of the LNG storage tank downstream of the odorizer. A heat exchanger manufactured by Artic Fox was installed to raise the gas temperature for the boiler gas inlet. The glycol loop consists of a 119 gallon capacity expansion tank and a glycol re-circulating pump which is 1.5 hp, 3-40 gpm with a 230 psig maximum working pressure. The system is connected to the LNG vaporizer with underground 1.5 inch diameter copper (type K) supply and return piping.

Odorant injection system – The system is designed to withdraw Mercaptan from a five gallon 150 psig vessel and inject the Mercaptan into the gas line downstream of the vaporizer at up to 5000 psig. According to NFPA 52 and the Texas Railroad Commissions Regulations for Compressed Natural Gas, vaporized gas must be odorized prior to entering the high-pressure storage vessel. When the high-pressure LCNG pump begins to compress liquid, the Opto controller opens a solenoid valve that allows gas pressure to be applied to the odorant pump through a pneumatic timer. The drive gas is routed through the adjustable timer, which can be set to cycle up to 50 times per minute. The pneumatic timer is currently adjusted to about 5 cycles per minute and the timer controls the 50:1 ratio, 1 cc odorant pump to inject the Mercaptan into the gas stream.

CNG storage vessel – The 60" diameter carbon steel CNG storage sphere, manufactured by Cherco is rated for 23,677 standard cubic feet capacity (approximately 190 gallons of CNG) at 5000 psig. It is constructed to ASME Section VIII, Division 2 standards, and maximum storage pressure is 5500 psig.

CNG Production Control System – The control system consists of an Opto22 LC32SX PC-Based controller with eight analog input/output and forty-eight digital input/output. The definition of each input/output point is listed in the strategy database (see Attachement P). This controller handles LNG pumping and LCNG delivery to the pressure vessel for storage. LNG Pump speed is governed by a Variable Frequency Drive, which allows precise control of pump speed. All other pumps are controlled with motor starters for On/Off operation. Dispenser sequencing is controlled by a Paragon Model MB2 by Micro – Monitor, Inc. through a Fueling Technologies, Inc. CNG dispenser. The Opto22 controller strategy (Program) was written in the Cyrano control language, a DOS based flow chart language. The strategy is owned by a third party and as configured has no provision for remote or local access for monitoring or troubleshooting. Alarms and messaging is handled by set of alarm lights on the controller front panel or messaging on the 4x20 display located on the LNG dispenser panel. Information is very limited and program documentation is nonexistent.

The CNG Production Sequence of Operation follows: Compressed Natural Gas (CNG) production begins when the CNG storage pressure drops below 3100 psig and the CNG Start/Stop switch is turned to Start. Cooldown of the low pressure LNG (Liquid Natural Gas) pump (P-1) begins by the opening of the LNG Pump Suction Valve (V-3) and the LNG Recirculation Valve (V-5) to allow LNG to gravity feed into the LNG pump. After the LNG pump has cold soaked for six minutes, the pump begins operating at approximately 3000 RPM. The pump continues to run at this speed for two additional minutes.

After the eight minute LNG pump cooldown time is complete. The LNG Recirculation valve closes, the Triplex Recirculation, Triplex Pump priming and Triplex Suction valves open. LNG is pumped through the LCNG High pressure pump and back to the top of the LNG storage tank in order to cool the LCNG pump, which is a seven minute timed process. After the cooldown timer has expired the LCNG pump is turned on. After 60 seconds the Triplex Recirculation is closed and pressurized LNG is diverted through the vaporizer, where it flashes to a gas. The gas continues on into the storage vessel. CNG production stops when the CNG storage pressure reaches 3600 psig.

CNG production can be stopped by depressing the Emergency Shutdown Button (ESD) or automatically by the control system. The controller monitors the current draw on the LCNG pump motor. If current drops below a user defined set-point the controller will stop the CNG production sequence and light the Loss of Prime light.

Card Access Controller – An AutoGas Systems, Inc. Island Master 144A card reader was installed on the cng fueling island to control the CNG dispenser. When the customer inserts his card, the card reader verifies a valid card and sends an authorization signal to the dispenser. During fueling, the Card Reader receives and records flow data from the dispenser flow meter. The data is collected daily via telephone lines using a personal computer loaded with AutoGas Site Management Software then used for monthly customer billing.

CNG Dispenser – The Fueling Technologies, Inc dispenser houses the flow meter assemblies and authorization valve for each hose. Of the two hoses on the dispenser is capable of dispensing CNG to 3600 psi. Current configuration has one hose established for 3600 psi vehicles and the other for 3000 vehicles. The NGV1 3000 psi nozzle fits on the 3600 psi vehicle recepticle. For safety reasons, the NGV1 3600 psi nozzle does not mate with 3000 psi vehicle recepticles, however. Once the authorization signal is received and the handle switch on the dispenser is lifted the authorization valve in the dispenser for that hose opens. The handle-on signal is sent to the CNG sequencing panel.

CNG Sequencing Panel – The Micro Motion, Inc. Paragon Model MB2 panel monitors and controls CNG fueling of the vehicle. After the panel receives the handle-on signal from the dispenser, the controller compares vehicle pressure to target pressure and bank pressure. If the vehicle is under target pressure, the controller opens the buffer valve between the bank and the vehicle hose and then gas begins to flow. The controller periodically (30 seconds is the setting we have used) closes buffer valve for several seconds (4 seconds) to compare vehicle pressure to target and bank pressure. If the vehicle pressure is at or above the target pressure, the MB2 controller will stop fueling. If the vehicle pressure is near, within 350 psi of, the bank pressure and the vehicle is not yet at target pressure, the MB2 panel will open the direct fill valve to complete fueling. Because the original design of the valve panel, this is really a buffer fill because gas is directed to both the storage tank and the vehicle storage at the same time. An improvement to this system will be discussed in the Improvements section of this report. The MB2 panel allows the technician to adjust all of the timing and pressure settings described above. During start-up, we adjusted these settings to provide for an accurate and fast fill.

Priority/Sequence Valves – Installed to control the flow of the gas from the vaporizer to the storage vessel or directly to the vehicle. The priority and sequence valves are ¼" air-actuated quarter-turn valves manufactured by SVF. The valve part number is P3666DB and the actuator part number is HS20-2C.

Photos

LNG Tank and Equipment 'Dog House' - South Side
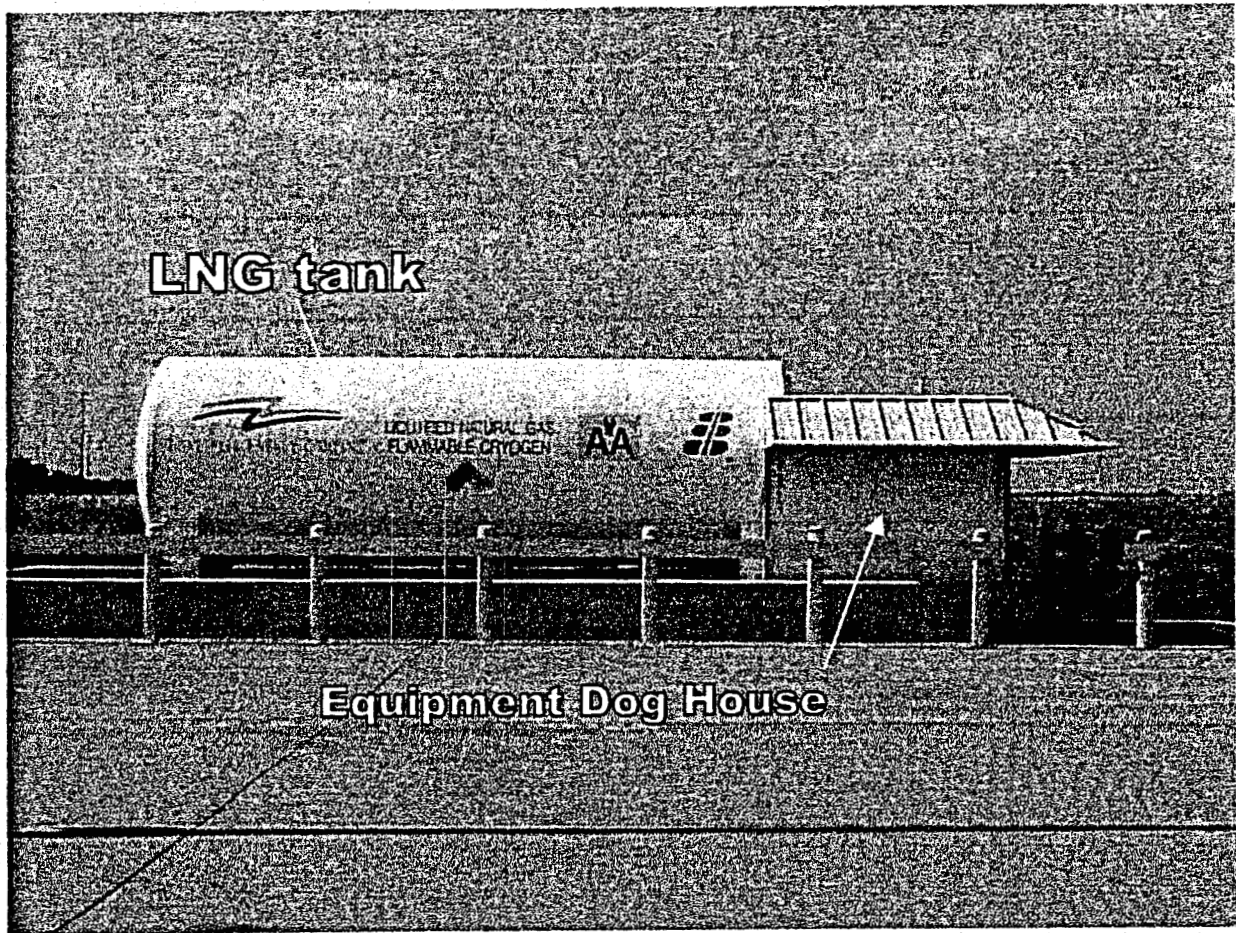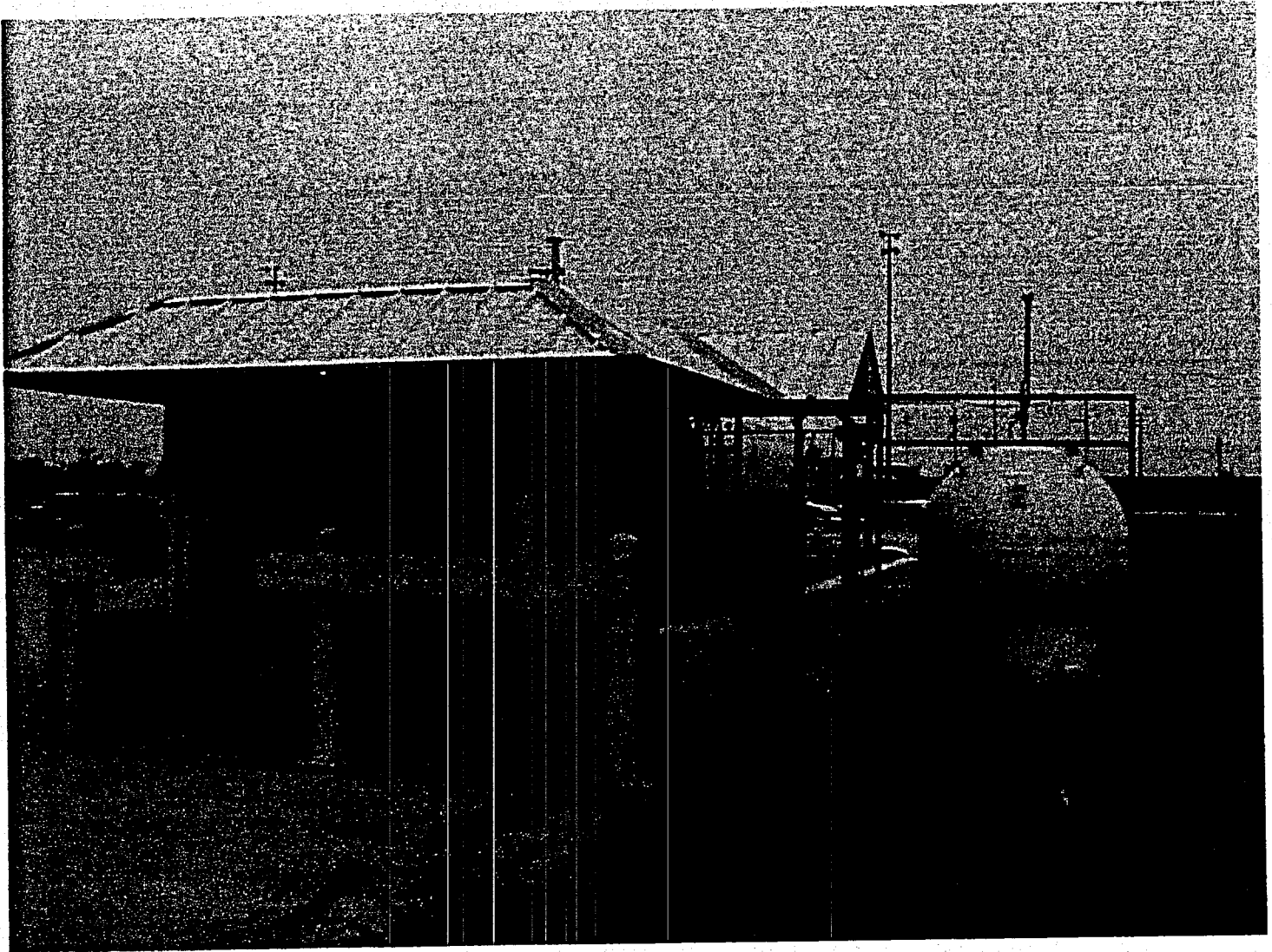
LNG Dog House East Side and CNG Storage Sphere
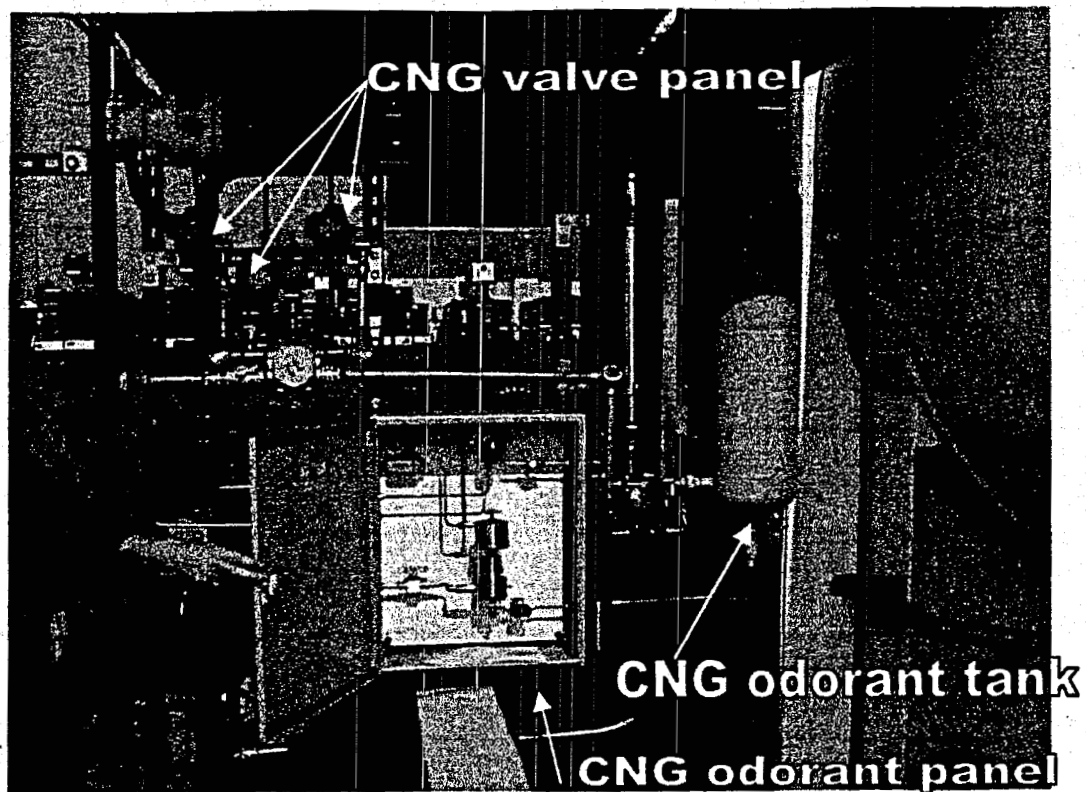
LCNG Equipment 'Dog House'
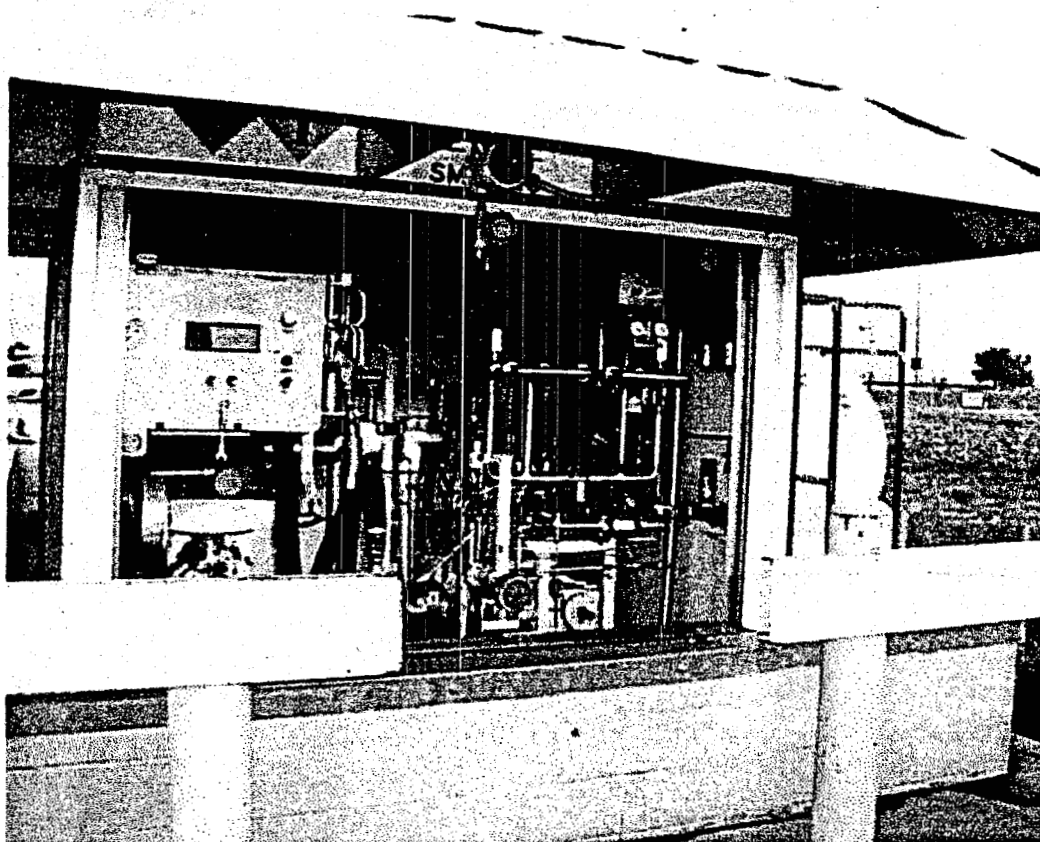
LNG pump suction

LNG tank - South side

To pressure building circuit

LNG pump suction

Saturation-coil

LNG tank - North side

To pressure building circuit

LNG tank & equipment

LNG tank & equipment

Sat coil circulation for pres building

To pressure building circuit

Top fill/recirc vapor side

Level gauge vapor side

Level gauge high pres liq side
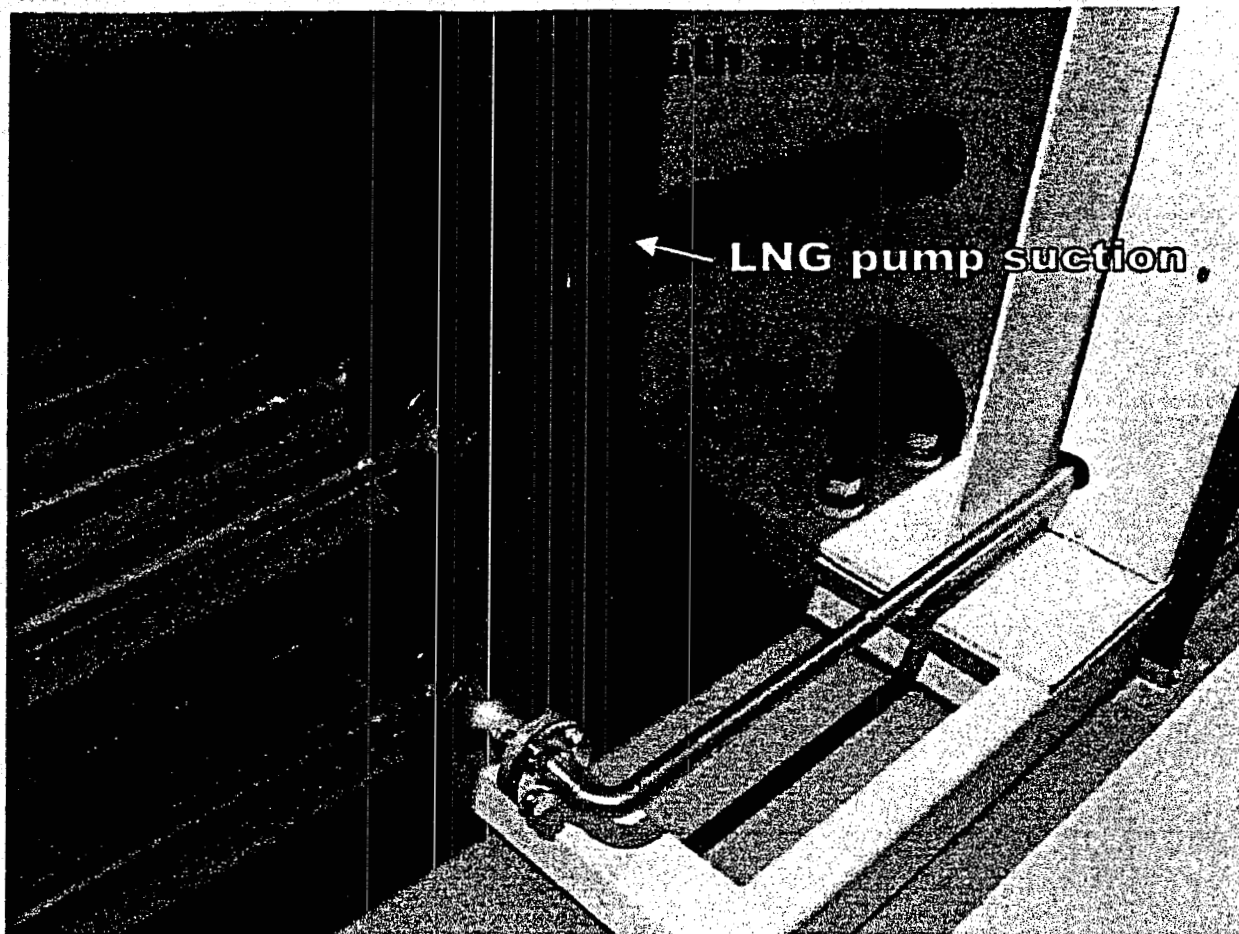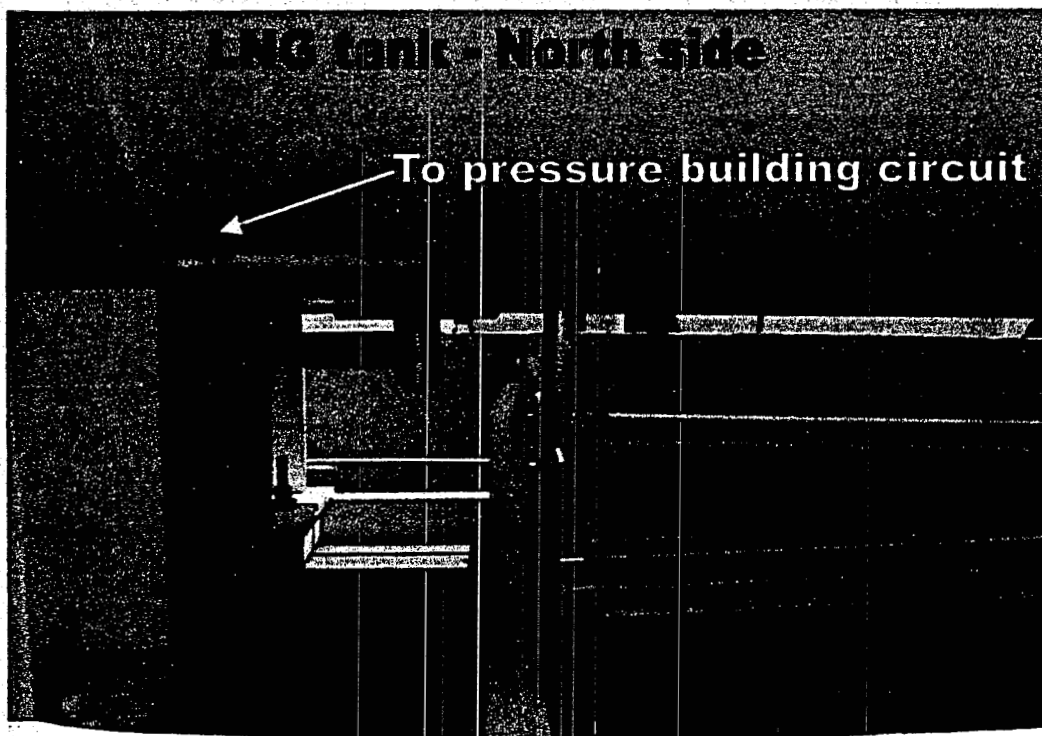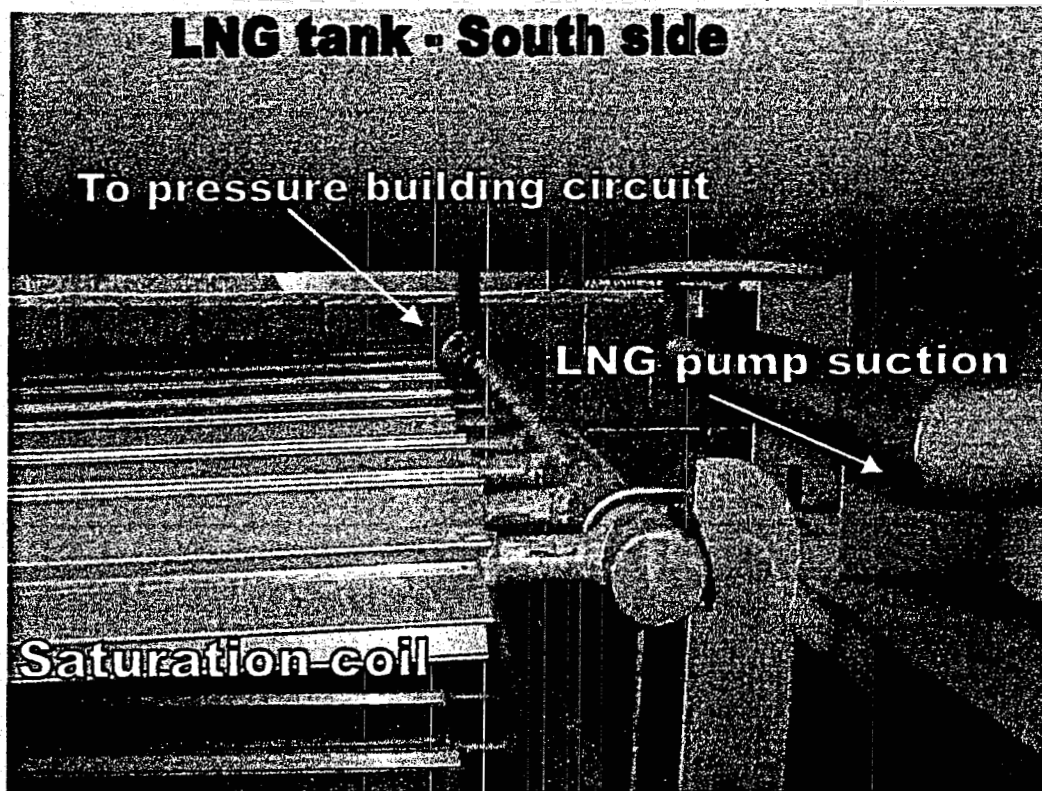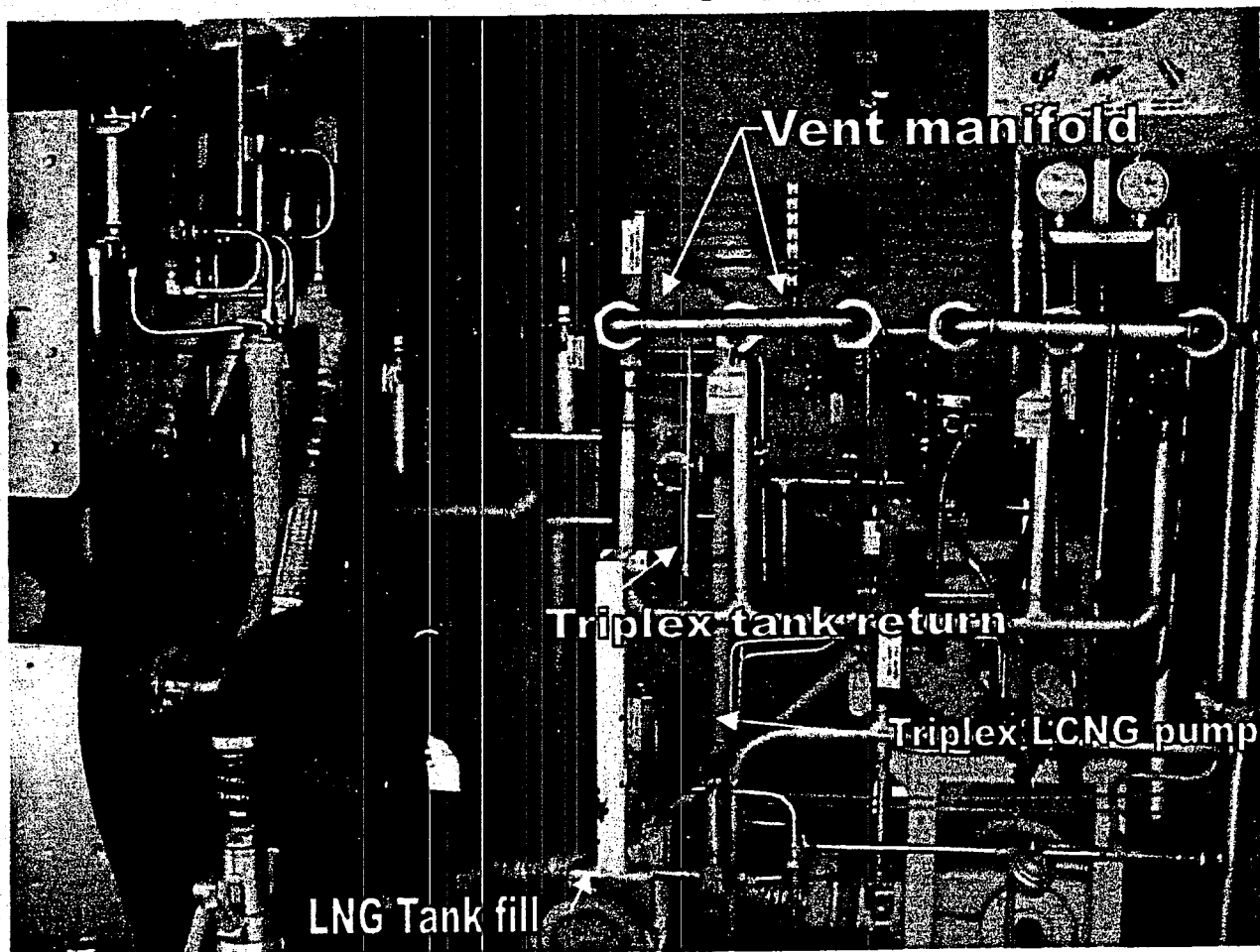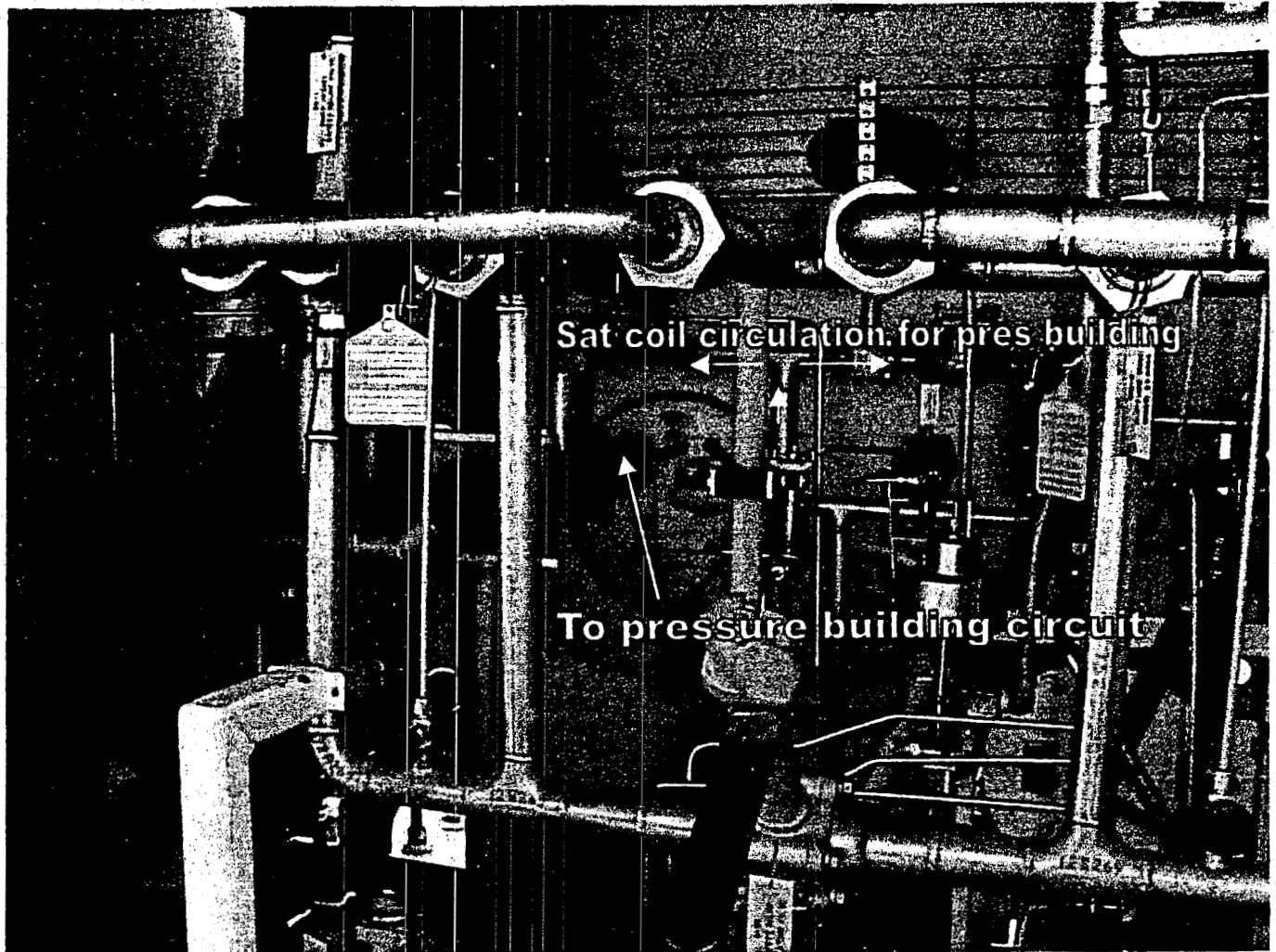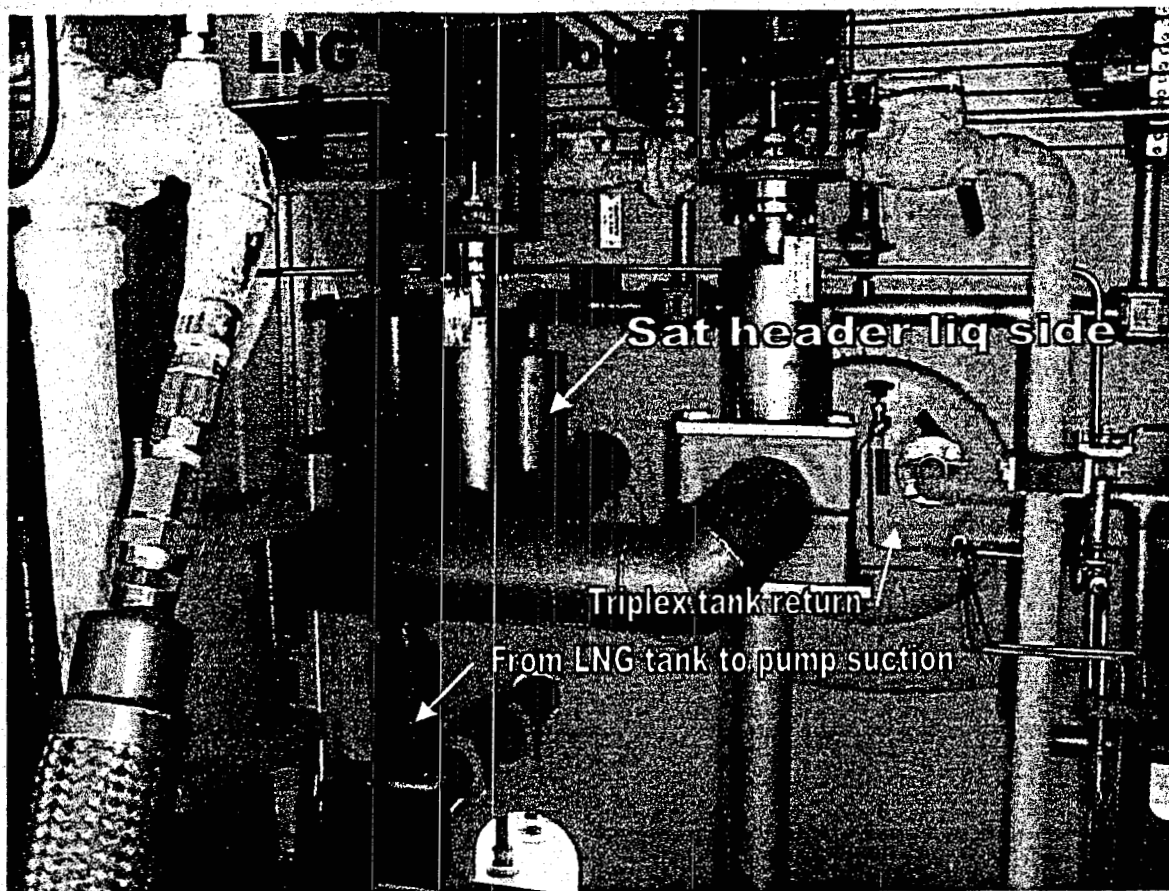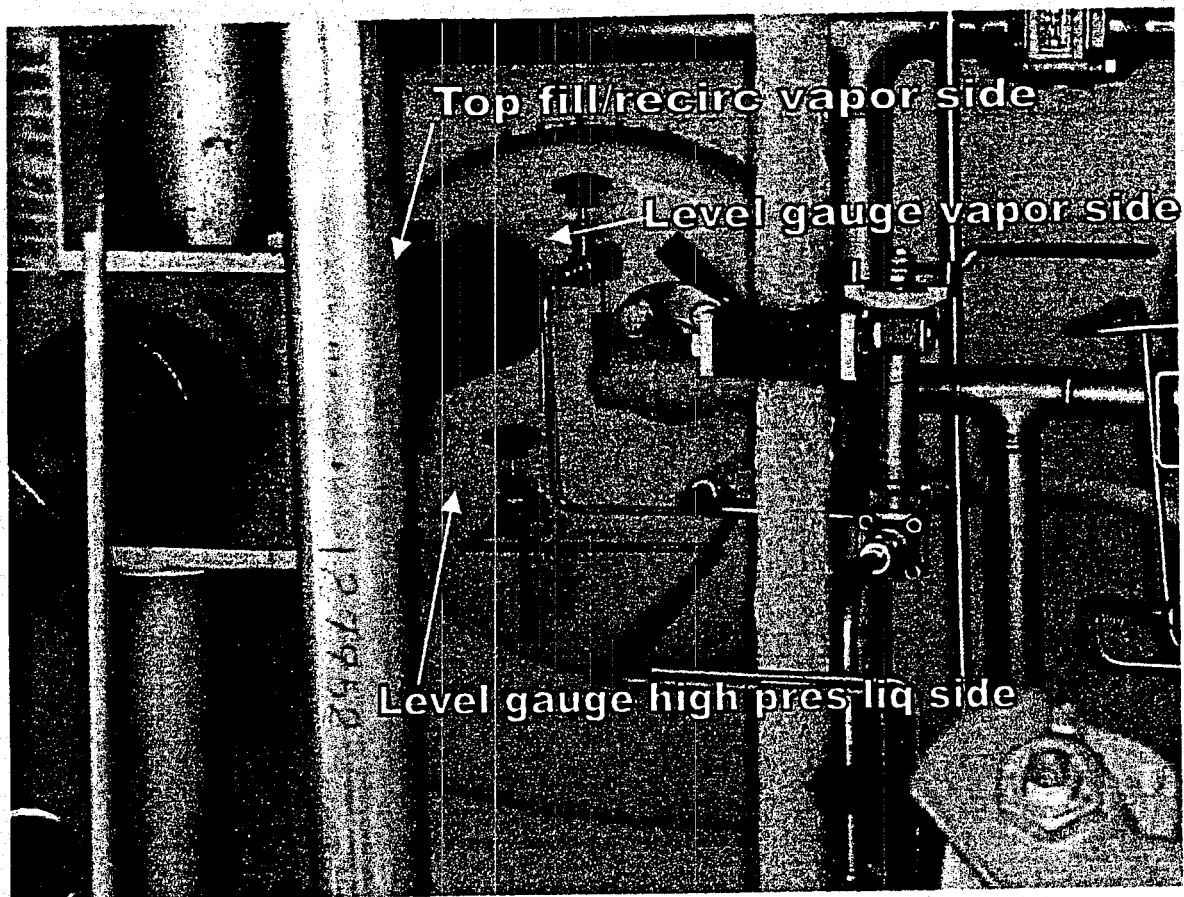
Task 1D - LCNG Facility Costs

Task 1D - LCNG Facility Costs

The objective of this task is to document a baseline of information on the total costs of building an LNG and LCNG fueling facility

QTY	UNIT	DESCRIPTION OF MATERIALS AND WORK	UNIT PRICE	AMOUNT	NOTES
		Original LNG Station Materials and Work			
1	ea	Drexel Hydra-Rig - Complete Closed-Loop Liquefied Natural Gas 6,000 Gallon Storage and Dispensing System	$262,200.00	$262,200.00	
1	ea	Civil and concrete work by American Airlines	$8,000.00	$8,000.00	estimated
1	ea	Electric work contributed by DFW Airport	$2,000.00	$2,000.00	estimated
				$272,200.00	
		L/CNG Station Materials and Work			
1	ea	Drexel Hydra-Rig - Addition of L/CNG pump module, controls, vaporizor, & piping to upgrade existing LNG station to L/CNG	$111,253.00	$111,253.00	
1	ea	Fueling Technologies twin-hose CNG dispenser	$22,928.00	$22,928.00	
1	ea	Cherco - 60 inch, 23677 scf CNG storage sphere	$23,588.50	$23,588.50	
1	ea	Autogas Systems, Inc. IM 144A CNG card reader (pre-wired for 6 hoses) w/ Seiko printer + Power cond.	$8,940.00	$8,940.00	
1	ea	Building addition to accommodate boiler and additional controls	$2,500.00	$2,500.00	estimated
1	ea	Grundfos Glycol Pump - CR4-30U, 1-1/2hp, 230/460VAC 3-phase 60hz, 3-40 GPM, 50 to 150ft of head	$439.20	$439.20	
1	ea	Arctic Fox Heat Exchanger, #SF-1562-24	$231.61	$231.61	
3	ea	Shell 55 Gallon Drums of Shell Zone or equivalent 50/50 Glycol/Water	$123.75	$371.25	
1	ea	Lochinvar 315,000 BTU water heater RWN315PM-F9 w/ flow switch and std. equipment and Lochinvar	$3,566.00	$3,566.00	
1	ea	Water Storage tank 125 psi T&P relief valve, remote tank Lochinvar TST2000 aquastat	$150.00	$150.00	
1	ea	Reynolds - Odorant Injection Pump Panel including: 6000 psi discharge pump, Pneumatic timer, & 5 gallon odorant storage vessel	$6,230.00	$6,230.00	
1	ea	J and M Industries - 10'x10' Canopy +2 Cooper Lights 400 W Super Metal Halide Lights	$3,316.00	$3,316.00	
2	ea	MSA Combustible Gas Sensor/ Transmitter, #487811	$570.00	$1,140.00	
1	ea	MSA Calibration Kit, #492770	$230.00	$230.00	
1	ea	MSA Calibration Gas, #491041	$136.45	$136.45	

1	ea	Federal Signal Alarm Light and Bell and Power Supply	$883.34	$883.34	
1	ea	Micro Mionitor Inc. MB-2 Two hose buffer storage and vehicle fill controller + 3 Pressure transducers	$4,870.00	$4,870.00	
1	ea	American General - Civil Work including demolition, trench work, concrete island, & canopy footing	$10,157.88	$10,157.88	
1	ea	United Mechanical - Plumbing materials & labor for controls, single bank storage & two hose dispensing valves for CNG system	$15,000.00	$15,000.00	estimated
1	ea	Maykin Electric - Electrical materials and labor for controls, single bank storage and two hose dispensing valves for CNG system	$7,500.00	$7,500.00	estimated
				$223,431.23	
		Replacement of Mono-block CNG Pump with 3 Cold-ends			
1	ea	Hydra-Rig Cryo-Cal Manifold Cold-end Suction Vent Line, # A28M1574	$4,077.90	$4,077.90	
3	ea	Hydra-Rig - Cryo-Cal Rebuilt Cold End; Bore .75", Stroke 1.890", # A28M1570	$2,000.00	$6,000.00	
1	ea	Hydra-Rig Cryo-Cal Intermediate Kit, # A28M1573	$5,848.20	$5,848.20	
2	ea	Spare parts Hydra-Rig - Cryo-Cal Rebuilt Cold End; Bore .75", Stroke 1.890", # A28M1570	$1,945.00	$3,890.00	
1	ea	Spare Parts Hydra-Rig - Cryo-Cal New Cold End; Bore .75", Stroke 1.890", # A28M1570	$3,890.00	$3,890.00	
				$23,706.10	
		Upgrades to accommodate 5000 psi storage pressure			
2	ea	Tescom Aluminum low-flow, active, adjustable regulator	$1,350.00	$2,700.00	estimated
2	ea	Tescom Aluminum High-Flow Dome Loaded Regulator (6000 psi pres., .375 Dia. Orifice, 1/2" port size)	$1,200.00	$2,400.00	
2	ea	Parker J-2 filter and fittings required to protect regulators	$361.74	$723.48	
2	ea	FlowsafeSafety relief valves	$224.00	$448.00	
				$6,271.48	
		Repairs and Additional Costs			
1	ea	NorthStar, Inc. - ACD Single Stage Pump	$9,499.00	$9,499.00	

1	ea	CryoCal Inc. - Rebuild burned-up ACD Single Stage Pump	$7,442.53	$7,442.53	
1	ea	United Mechanical - manufacture and install spool piece to replace low-flow LNG pump	$1,211.00	$1,211.00	
4	ea	Cryocal - Set of 3 Soft-good and hardware rebuilds	$3,000.00	$12,000.00	estimated
4	ea	Tescom regulator rebuild kits	$40.00	$160.00	
1	ea	Reynolds - Rebuild Odorant Injection Pump	$850.00	$850.00	
				$31,162.53	
	Total			$556,771.34	

Reference Documents

- *NFPA 52*
Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems
1995 Edition

- *NFPA 57*
Standard for Liquefied Natural Gas (LNG) Vehicular Fuel Systems
1996 Edition

- *NFPA 59A*
Standard for Liquefied Natura' Gas (LNG) _
1996 Edition

- *Regulations for Compressed Natural Gas*
Railroad Commission of Texas
Gas Services Division
LP-Gas Section
Revised March 1999

- *Regulations for Liquefied Natural Gas*
Railroad Commission of Texas
Gas Services Division
Revised October 1997

- *LNG Material Safety Data Sheet*
User's Guide 1995
Amoco Corporation

- *Mercaptan Material Safety Data Sheet*

- *Pressure Vessel Code*
California Department of Occupational Safety and Health (CA OSHA)
Title 8

Attachments

Attachment A
Lone Star Energy Company Background Statement and Resume

Attachment A

Lone Star Energy Company Background Statement

Business and Operations Profile

The Company is the Alternative Fuels Division ("AFD" or the "Company") of TXU Gas Company ("TXU Gas"), a wholly owned subsidiary of TXU Corp and formerly known as Lone Star Energy Company. TXU is an investor-owned holding company for energy services companies headquartered in Dallas, Texas. The TXU system includes companies engaged in domestic and international electric and natural gas utility services, energy marketing, telecommunications and other energy-related services. TXU owns and operates more than 29,000 megawatts of electricity generation, serves 8.5 million customers primarily in Texas, the United Kingdom, and Australia, has proforma annual revenues of $17 billion and assets of $40 billion.

The Company is a nationally recognized market leader in the development and commercialization of natural gas fuels and related services for the transportation market. Its customer base includes major public and private sector fleets in the Texas region. The Company's primary market area includes large metropolitan areas where compliance with the EPA's air quality standards is a priority, including emissions reduction from mobile sources.

Products and services provided by the Company include retail and wholesale CNG/LNG fuel distribution and transportation, public and private infrastructure development services and vehicle conversions and services. Contracts are currently in process with federal, state and local agencies to further market and technology development.

TranStar Technologies, L.L.C.

TranStar was formed in December 1991 to provide natural gas vehicle conversions and equipment services. Based in a 20,000 square foot conversion facility near downtown Dallas, TranStar provides equipment sales and warranty service, turnkey vehicle conversions and driver and mechanic training programs. TranStar has been associated with the conversion of more than 3,000 vehicles to natural gas service since June 1992. TranStar is known for making objective equipment recommendations based first on customers' needs. TranStar also provides full-service upfitting for pickups, cargo vans and cab/chassis for commercial, industrial, agricultural and personal uses as an extension of the vehicle conversion business. Upfitting meets the needs of specific projects with product lines consisting of flat beds, cranes, service bodies, dump bodies, van bodies, tool boxes, cargo van shelving, ladder racks and lift gates.

FleetStar of Texas, L.C.

Also formed in November 1991, FleetStar provides public CNG fueling facilities and computerized fleet management services. Recently, all new CNG fueling stations have been

constructed and operated by AFD outside of the FleetStar partnership. AFD and FleetStar combined currently own and/or operate 21 public and private CNG fueling stations in the greater DFW area and one in Waco. These stations, four of which are owned by FinaStar, are automated, unattended card-access stations open 24 hours per day to fleets and other users.

Products and Services

The Company's products and services are a key component to solving its service area's growing pollution problem. Motor vehicles emit more than 50% of all hazardous air pollutants and are a major source of greenhouse gases, contributing nearly 60% of carbon-based emissions in the Dallas-Fort Worth Metroplex.

CNG/LNG Fuels

AFD is the sole provider of CNG fuel in the four-county region of the Dallas-Fort Worth Metroplex and the primary supplier of LNG fuel and related services in Texas. Today, it is estimated that more than 4,000 vehicles purchase nearly 9 million gasoline gallon equivalents of CNG and gallons of LNG annually in the Company's market area

The Company is the area's sole provider of publicly accessible natural gas fueling stations. The enterprise owns in whole or in part 20 stations in the Metroplex and Waco. Additionally, the Company supplies fuel to 17 private LNG and CNG fueling stations, many of which it constructed.

In addition, the Company is the prime contractor to construct two major LNG storage and dispensing systems (one 60,000 gallon and one 40,000 gallon) for Dallas Area Rapid Transit ("DART") in Dallas and to supply LNG for a five-year period. During 1999, the Company completed state-of-the-art fueling infrastructure projects valued at $4 million for DART and the Fort Worth Transit Authority. A number of additional projects are under development for major customers.

Credit Card Payment and Tracking System

Through FleetStar, AFD has licensing rights to a fuel management system, called the AutoGas Site Management System ("SMS"), which offers easy-to-use card-activated pumps and comprehensive monthly management reports tracking fuel costs and usage.

The SMS is a software system designed to run on an IBM, or IBM-compatible, personal computer. SMS communicates via remote modem (on-site communication by PC) with the card reader/control unit at each site. It provides a means of defining and sending site-unique information to, and retrieving site-generated information from, the card reader/control unit. The card reader/control unit interfaces with the other components at the site. In essence, SMS provides an automated method of selling fuel and gathering the information needed to receive

payment for that fuel. This automation allows the Company's customers access to CNG 24 hours a day, seven days a week, without the necessity of an on-site attendant.

The type of information exchanged between SMS and the site control unit includes site information, proprietary card information and sales information.

- Site Information - this category of information identifies the site (address and site number) and describes the equipment installed at the site. Such information includes the types of dispensers used, the cards accepted at the site and the designation of which network validates the cards. Also identified by site are the fuel products offered, the price for each product and the time of day site information is collected by SMS.

- Proprietary Card Information - this category provides information pertaining to proprietary cards such as generating PINs, assigning card numbers, encoding cards, validating cards, setting card purchase limits and limiting card use to certain hours. The FleetStar card, which is issued to customers who drive natural gas powered vehicles, is a proprietary card. It along with the Fina-FleetStar Fleet card, a non-proprietary WEX Network approved card, are the only two cards accepted as payment for CNG purchases at Company operated sites.

- Sales Information - the sales category includes information regarding collection of transaction information by SMS, processing collected transactions, and reporting transaction information. This transaction data is sorted and later used to produce month-end customer billings.

The SMS application is a powerful yet flexible software package. Previous editions of the software package have been DOS-based. AutoGas has recently developed a new Windows®-based SMS platform. The on-line help for many prompts and a user-friendly design of the Windows® version make SMS an easy-to-use site management, billing and reporting tool. The Company implemented the new Windows®-based software, as well as site controller firmware updates, as of October 15, 1999. The new version software and firmware is expected to bring the SMS system into year 2000 compliance.

Public and Private Infrastructure Development

The Company's operating philosophy encourages public/private ventures, allowing customers the opportunity to locate natural gas fueling stations on their property to conveniently service their fleet, while allowing the Company the opportunity to market CNG to third-party customers from that location. This cooperative effort provides cost-effective, privately accessible CNG fueling stations while fostering the expansion of the public CNG station network that is critical to long-term success of this business. Dallas County was the first customer to utilize this option. This public/private venture opened in early 1994 on the western edge of the downtown Dallas business district and is currently the Company's largest-volume publicly accessible CNG station.

Vehicle Conversion and Upfitting

In TranStar, the Company owns the area's leading source of expertise capable of converting diesel and gasoline engines to the use of LNG or CNG.

TranStar provides natural gas vehicle conversions including equipment sales and warranty service, turnkey vehicle conversions and driver and mechanic training programs.

The conversion business was a requirement initially because there were no OEM NGV models available to fleet customers. As a result, the Company was required to be in the conversion business to ensure that customers would have quality installation and maintenance services. In recent years, OEMs have begun offering a larger selection of light-duty NGV models each year.

TranStar also provides full-service upfitting for pickups, cargo vans and cab/chassis for commercial, industrial, agricultural and personal uses as an extension of the vehicle conversion business. Upfitting meets the needs of specific projects with product lines consisting of flat beds, cranes, service bodies, dump bodies, van bodies, tool boxes, cargo van shelving, ladder racks and lift gates.

Service Area

The Dallas-Fort Worth Metroplex and other major metropolitan markets in Texas are in various stages of non-attainment relating to compliance with EPA air quality requirements. In Dallas-Fort Worth specifically, 50% of emissions come from on-road mobile sources and another 34% come from off-road mobile sources, indicating that the fast-growing area will only improve its air quality status through initiatives including increased use of clean-burning alternative fuels.

Employees

The Company's management/employee team has been with the business over its nine-year development cycle and is believed to be a key asset of the business. This 23-member team has more than 150 years of combined work experience in numerous fields, including construction and operations, engineering, mechanical, and electrical and technical fields. In addition, the team brings with it a full complement of accounting, administrative, clerical/secretarial and marketing and sales staff

Licenses and Permits

Certain individual employees are required to hold licenses from the State of Texas or be certified by the Texas Railroad Commission. The Company and its affiliates hold the following licenses from the State of Texas and the Texas Railroad Commission:

Lone Star Energy Company

Railroad Commission of Texas-CNG License   No. 00102   Expires February 28, 2001

Railroad Commission of Texas-LNG License   No. 10515   Expires October 31, 2000
Renewal Pending

TranStar Technologies, L.L.C.

State of Texas Motor Vehicle Converter's   No. 0018   Expires October 31, 2000
License   Renewal Pending

Railroad Commission of Texas-CNG License   No. 00106   Expires February 28, 2001

FleetStar of Texas, L.L.C.

Railroad Commission of Texas-CNG License   No. 00096   Expires February 28, 2001

Attachment B
NorthStar Inc. Background Statement

NORTHSTAR, INC.

P.O. Box 1342
Evanston WY 82931

180 Mountain View Drive
Evanston WY 82930
307/789-5088 Phone
307/789-8062 Fax
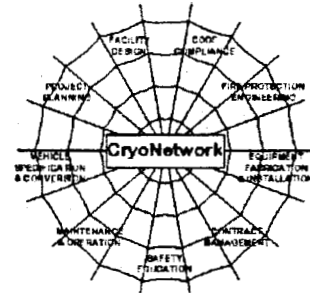
Dear Prospective Client:

Thank you for your interest in NorthStar LNG equipment! We feel that NorthStar is in a unique position to provide you a successful turnkey LNG project. With five years of experience in LNG equipment and operations, our company strengths are in:

- Securing Permits and Regulatory Approval
- Site Improvements
- LNG Station Maintenance

- LNG Equipment Design & Manufacturing
- Cryogenic Equipment Installation
- Operational Training

Enclosed are a list of professional references and a photo album of NorthStar LNG projects. Our best advertising comes from our previous customers -- we encourage you to call any of the references listed for an evaluation of our work.

LNG equipment and service is our primary business. To expand our company capabilities, we have teamed with General Physics Corporation and Gage-Babcock & Associates to form **CryoNetwork**. This alliance allows us to provide LNG facilities on a design-build basis including civil, mechanical, electrical, and fire protection engineering. An attached letter further explains the advantages of this team approach. Our web site under construction is www.cryonetwork.com.
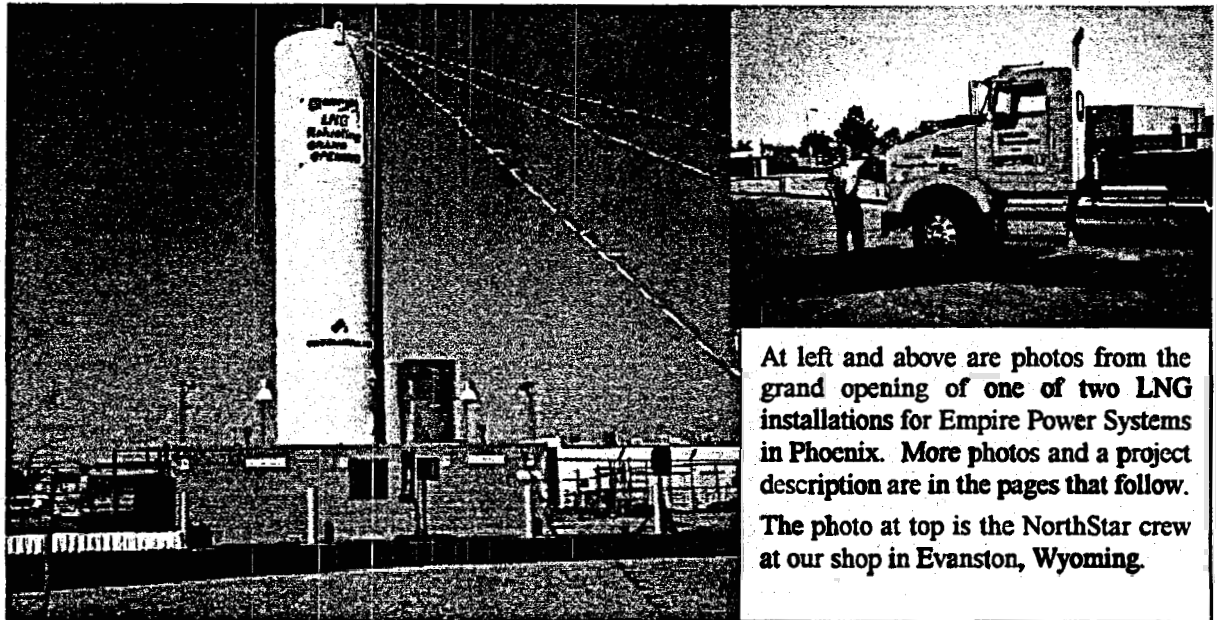
At left and above are photos from the grand opening of one of two LNG installations for Empire Power Systems in Phoenix. More photos and a project description are in the pages that follow.

The photo at top is the NorthStar crew at our shop in Evanston, Wyoming.
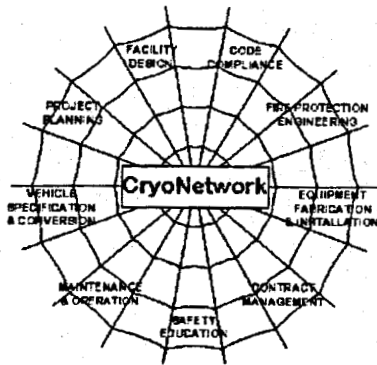
NORTHSTAR INC.

GAGE-BABCOCK & ASSOCIATES
Fire Protection, Life Safety, & Security

WELCOME TO CRYONETWORK!

CryoNetwork is a team of companies dedicated to providing successful alternative fuel project design / build services. **CryoNetwork** is made up of Engineering firms, consultants, and equipment suppliers known for their professional expertise, superior quality of work, and ability to work as an integrated team. **CryoNetwork** team members are:

General Physics	NorthStar Inc.	Gage-Babcock & Assoc.
Escondido CA	Evanston WY	San Francisco CA

This unique team of cryogenic professionals has the ability to provide design / build services for:

> ➤ LNG and CNG Vehicle Refueling Facilities
> ➤ Natural Gas Vehicle Maintenance Facilities
> ➤ Cryogenic Systems for Atmospheric Gases (Nitrogen, Oxygen, and Argon)
> ➤ Recertification / Refurbishment of Existing Cryogenic Facilities

By combining our individual company talents, we can provide a wide range of services such as:

> ✓ Project Planning
> ✓ Facility Design
> ✓ Regulatory Compliance
> ✓ Fire Protection Engineering
> ✓ Equipment Fabrication & Installation
> ✓ Facility Maintenance & Operation
> ✓ Safety Education
> ✓ Natural Gas Vehicle Specification & Conversions

For more information on **CryoNetwork**, visit our web page (under construction) at www.cryonetwork.com or contact:

Mike Mackey
General Physics Corporation
2430 Vineyard Avenue, Suite 103
Escondido CA 92029
760/233-9880
760/233-9881 fax
mmackey@genphysics.com

Tom Chrisfield
NorthStar, Inc.
PO Box 1342
Evanston WY 82931
952/953-6261
tomchr@charter.net

✦ NORTHSTAR INC.

Post Office Box 1342
Evanston WY 82931
Phone (307)789-5088
Fax (307)789-8062

Qualifications

NorthStar has experience in the design, fabrication, installation, operation and maintenance of LNG and LCNG fueling facilities. NorthStar has had the opportunity to work with some of the leading companies that have been involved in LNG fuel supply and LNG equipment such as Applied LNG Technologies, Amoco, Empire Power Systems, LNG Energy, Lockheed Martin (INEEL), Lone Star Energy, MK Rail, Pickens Fuel Corp., and Santa Fe Rail Road. In the five years NorthStar has been dedicated to the LNG business, the company has grown from performing equipment installations, to providing station operation & maintenance, to manufacturing equipment, to executing turnkey LNG station packages. NorthStar is unique in the LNG business, with the ability to:

- Prepare Civil, Electrical, & Mechanical Drawings
- Secure Building Permits
- Perform Site Improvements

- Manufacture and Install Engineered LNG Systems
- Perform Commissioning and Training
- Provide Superior After Sales Service

References

ATC/VANCOM
Donald Roose, Maintenance Manager
Phone 480/966-7744

Applied LNG Technologies
Steve Bartlett
Phone 806/355-5679 x267

Empire Power Systems
Mike Shannon
Phone 602/333-5601

Harris Ranch Feeding Co.
Manny DeLaOssa
Phone 877/999-1812

Lockheed Martin (INEEL)
Kevin Brown, Fleet Technical Supervisor
Phone 208/526-2075

Lone Star Energy
Stan Taylor, Construction & Engr. Manager
Phone 214/573-3854

Pickens Fuel Corp.
Jim Harger
Phone 562/493-2804

Sun Metro Transit
Wes Swenson, Maintenance Chief
Phone 915/534-5874

NorthStar Contact List

	Phone	Fax	Mobile
Tom Chrisfield	952/953-6261	952/953-6261	612/747-6344
Bob Oldham	307/789-5088	307/789-8062	801/231-8393
Mark Oldham	307/789-5088	307/789-8062	801/231-6720
John Reynolds	307/789-5088	307/789-8062	801/209-3314

Project Experience

City of Tulare   **Tulare, California**
LNG / LCNG Fuel Station   **September 2000 – May 2001 (projected)**

The CryoNetwork team of General Physics and NorthStar has been selected to install new natural gas fueling equipment for the City of Tulare. City vehicles, local school buses, and local trucking firms will benefit from this public / private partnership. The drawings below are representative of the equipment to be installed at Tulare.
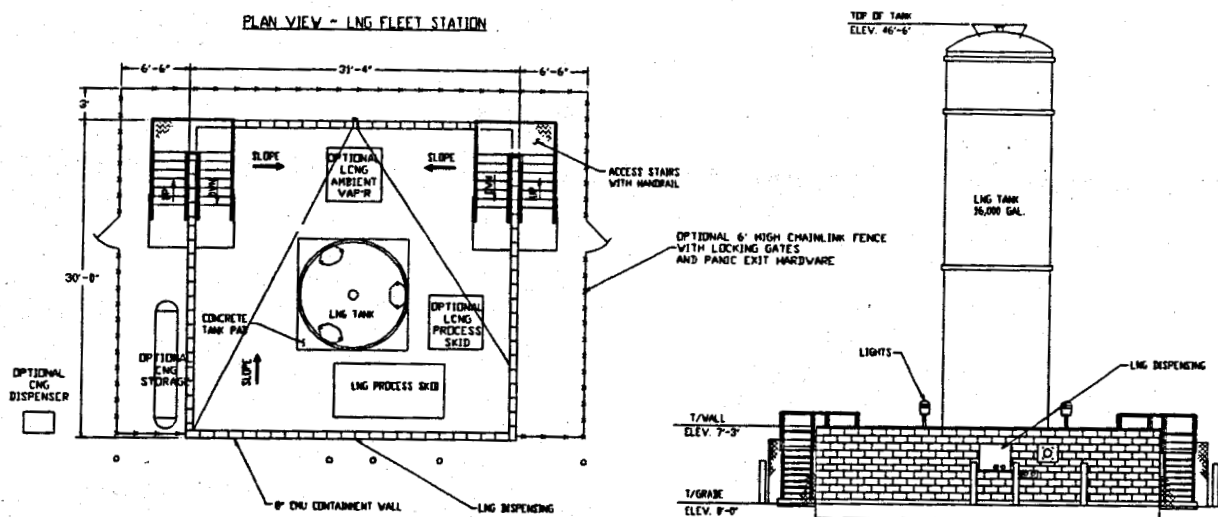
Pickens Fuel Corp.   **Thousand Palms, California**
LNG Fuel Station   **September 2000 – March 2001 (projected)**

Liquefied natural gas will soon join the alternative fuel plaza at SunLine Transit in Thousand Palms. SunLine is repowering 3-5 transit buses / coaches to LNG. In partnership with PFC, public fueling will be provided as well. The station will also be a link along the Interstate Clean Fuels Transportation Corridor (ICTC) between Phoenix, AZ and Los Angeles, CA.

Waste Management will locate two new Mack roll-off trucks and repower seven existing roll-off trucks with Cummins 8.3C engines. These nine LNG trucks will also fuel at the PFC / SunLine station.

Pickens Fuel Corp.   **Corona, California**
LNG Fuel Station   **September 2000 – February 2001 (projected)**

NorthStar is thrilled to have been selected by Pickens as a preferred vendor for new liquid natural gas fueling projects. Waste Management of the Inland Empire will locate 20 new and 14 repowered refuse haulers at their facility in Corona.

Applied LNG Technologies   **Phoenix, Arizona**
LNG Fuel Station   **April 2000 – July 2000**

An ALT TVAC skid had been in service at the ATC/VANCOM location since spring 1999. With an ever increasing number of transit vehicles operated by ATC/VANCOM, the original equipment had a difficult time keeping up with fueling demand. ALT had the foresight to provide a second concrete pad for future expansion. NorthStar installed this Fleet Station and fueled the entire fleet less than three weeks from receipt of permits.
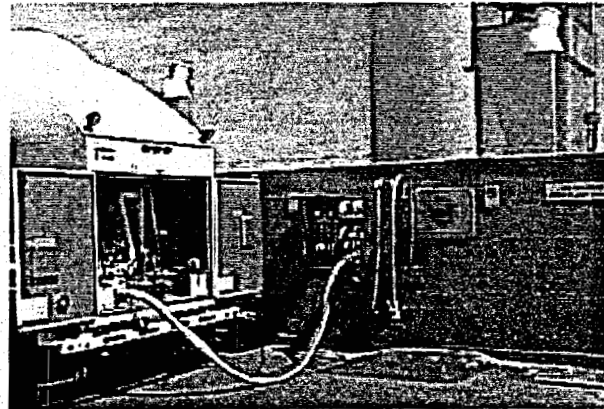
The Fleet Station has superior performance in transport offload time and fuel saturation time. An LNG transport can offload 10,000 gallons of fuel in 60 minutes (gate-to-gate). All controls and valves are accessible from outside the containment area. Preparing the fuel (saturating) is accomplished in 15-20 minutes. What this translates to is a minimized station downtime of less than 90 minutes.
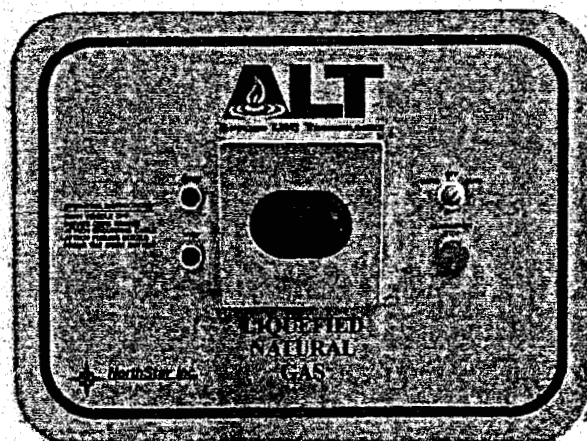
The dispenser face is easy to read and simple to operate. In addition to fueling information, operator messages and alarm status are displayed.

Empire Southwest
LNG / LCNG Fuel Stations

Phoenix and Mesa, Arizona
August 1999 –February 2000, August 2000

NorthStar was contracted by Empire Southwest, parent company of Empire Caterpillar, to provide two turnkey LNG facilities for trucks to be operated in the Phoenix area. The goal is for at least 200 trucks to be converted by Empire using Caterpillar Electronic Dual-Fuel engines. Both the site below, and the Mesa location on Empire's service lot, will be open for card-key public access. NorthStar provided all design work and secured permits. Site improvements and installation of equipment were completed in February 2000. High-pressure LNG pumps have been added at both locations to produce and dispense CNG for public fueling.
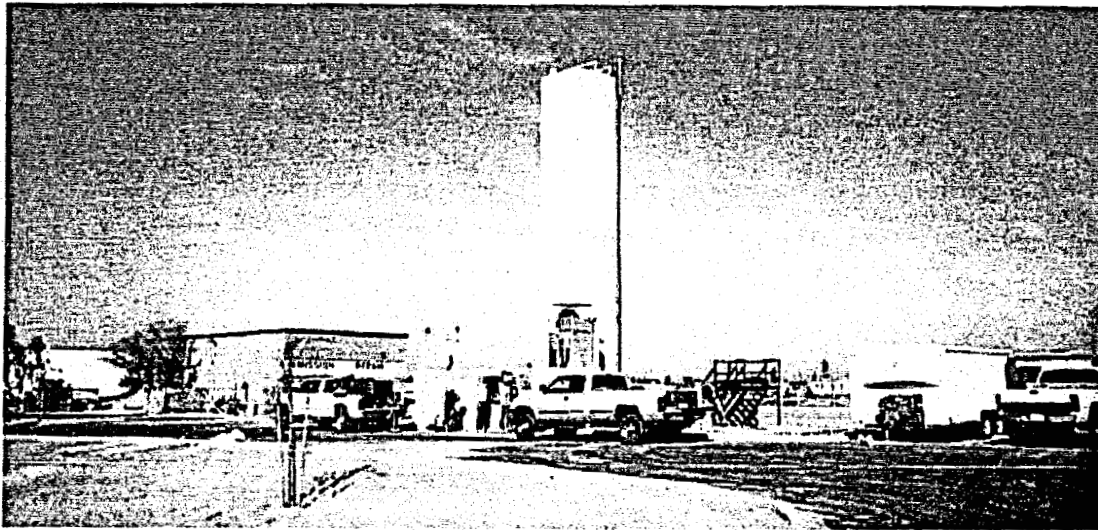
During construction, NorthStar is on site with a small fleet of Dodge trucks, fabrication trailer, and welding rig. By performing our own mechanical work, we can both minimize installation time and assure the highest quality workmanship. In the photo below, former Arizona Speaker of the House Jeff Groscost makes a point about improving air quality in the Valley of the Sun.
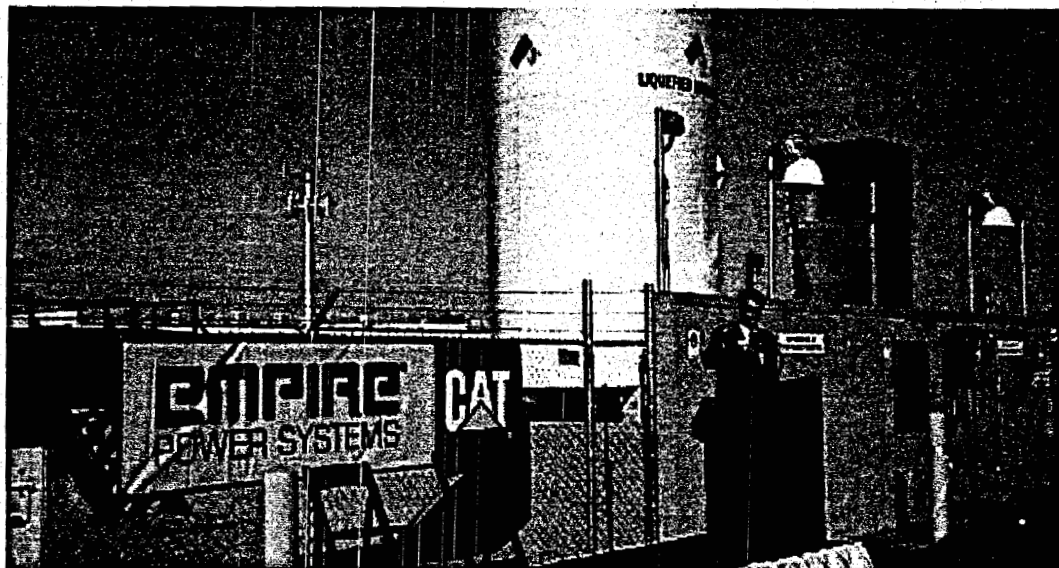
Harris Ranch Feeding Company   Coalinga, California
LNG Fuel Station   April – August 1999

NorthStar furnished a turnkey LNG facility to fuel a portion of HRFC's truck fleet. NorthStar provided detailed designs, secured permits, prepared the site, provided & installed all process equipment, commissioned the equipment, and provides a one-year performance warranty. From date of contract award to the first vehicle fueled was four months. The station is the first in California to comply with pending CA/OSHA Title 8 regulations.

Twelve 1999 Freightliner Century Class chassis have been upfitted with Caterpillar Electronic Dual-Fuel C-12 410 horsepower engines. The first LNG station on the Interstate 5 Clean Transportation Corridor, this site is within a mile of I-5 at the highway 145 exit. Card-key public access is available.
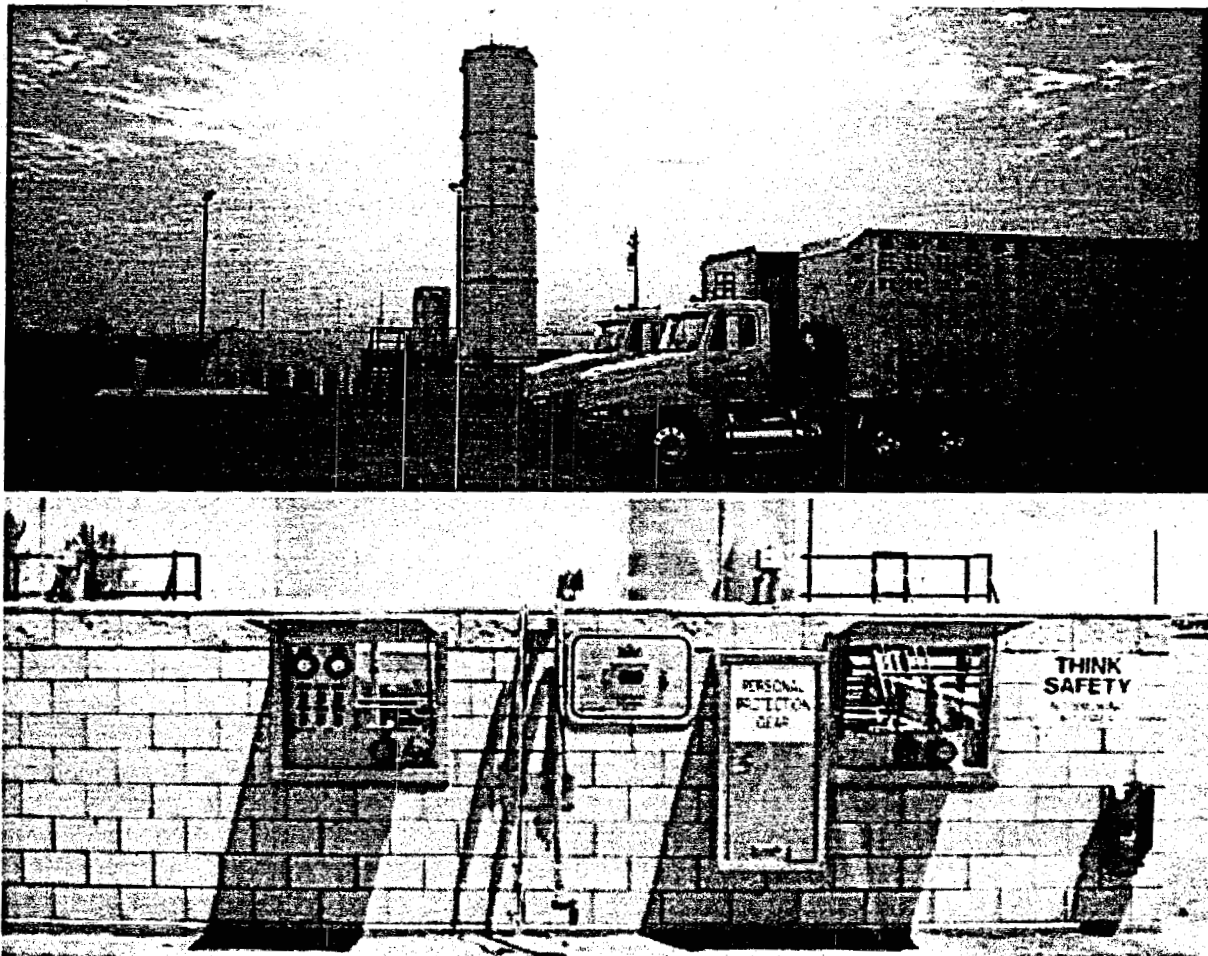
The dispenser control panel, as well as access doors to the transport offload connections, are mounted flush with the front containment wall. Two methane detectors monitor the fueling area.

With the doors open, process piping connections for offloading a transport or manual operation are accessible. The panel on the left has pressure gauges to monitor pump performance, manual air valves to operate key process valves, and the primary transport offload connections. The panel on the right allows access to a second set of pump controls and transport connections for an optional ground-mounted offload pump.

Harris Ranch Feeding Company **Coalinga, California**
LNG Fuel Station (continued) **April – August 1999**

The NorthStar Fleet Station dispensing system is designed to support a single-hose fill with no vapor returned to the station. Dispensing rates of 30-50 gpm are typical. For those instances of high vehicle tank pressure due to non-use of the vehicle or a first fill, a vent hose is available. NorthStar uses a stainless steel fill hose selected for its combination of strength and flexibility.

The dispenser operation has been kept as simple as possible. The operator authorizes the fuel management system by swiping a card, attaches the LNG fill hose, and pushes the Start button. The control system will automatically terminate fuel flow when the tank is full. Gallons of fuel dispensed and price are displayed, along with messages to prompt the operator or warn of an alarm condition. The color display is much easier to read than this photo shows.

Sun Metro Transit **El Paso, Texas**
LCNG Pump Replacement **August 1999**

NorthStar replaced an existing LCNG pump with a new ACD model 2-GAPD duplex pump capable of 8 gpm flow at 5000 psig discharge. The new pump saves approximately an hour of CNG bus fueling time each night, and off-site fueling is no longer required. With a service contract from Sun Metro for pump rebuilds, NorthStar is able to provide a three-year equipment warranty.

Phoenix Transit **Phoenix, Arizona**
LNG Pump Addition **August 1999**

NorthStar added a 250-gpm LNG pump to allow for faster offload of LNG transports and reduced tank venting. NorthStar provided detail drawings, secured all required permits, and installed & commissioned the pump.

Tempe Transit **Tempe, Arizona**
LNG Fueling Equipment **July 1998 - March 1999**

Under contract with Pickens Fuel Corp., NorthStar installed an LNG fuel station using customer-supplied storage tanks. Site improvements were performed by PFC. NorthStar designed and fabricated the LNG dispensing system including controls. The facility currently fuels more than 50 buses with an average daily use of 3800 gallons of LNG. The fleet is expected to grow to 108 vehicles.

Lone Star Energy **Dallas, Texas**
LNG Pump Skids **December 1998 - March 1999**

NorthStar fabricated two LNG pump skids to allow Lone Star to support future LNG fuel station opportunities. Incorporating a submerged centrifugal pump from ACD, these skids can provide fuel to vehicles at rates of 30-50 gpm. Packaged as a skid, the units allow for rapid installation in the field. The units are nearly identical to pump skids at Tempe, Harris Ranch, and Empire.

Dallas Area Rapid Transit
LNG Fueling Equipment

Dallas, Texas
January & December 1998

Under contract with Lone Star Energy, NorthStar designed and fabricated two LNG pump skids to provide bus fueling for DART at the Northwest and South Oak Cliff sites. Each skid features three submerged LNG pumps, and supports three LNG dispensers with flow rates of 40-60 gpm per vehicle.
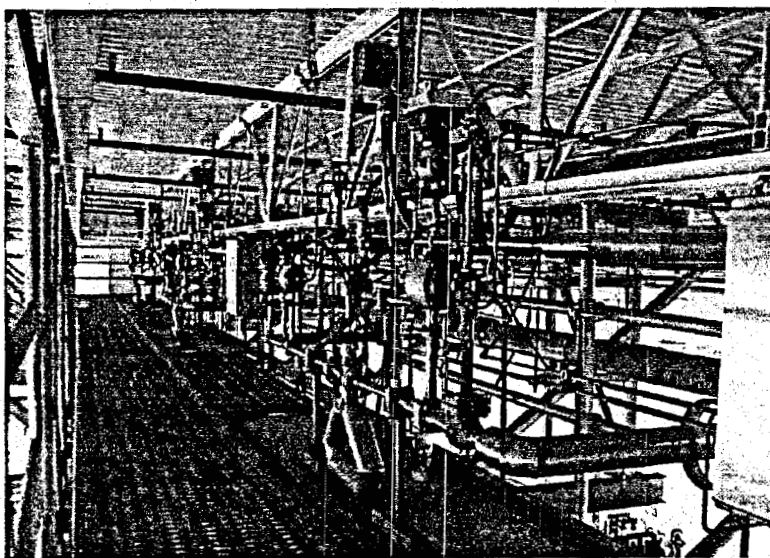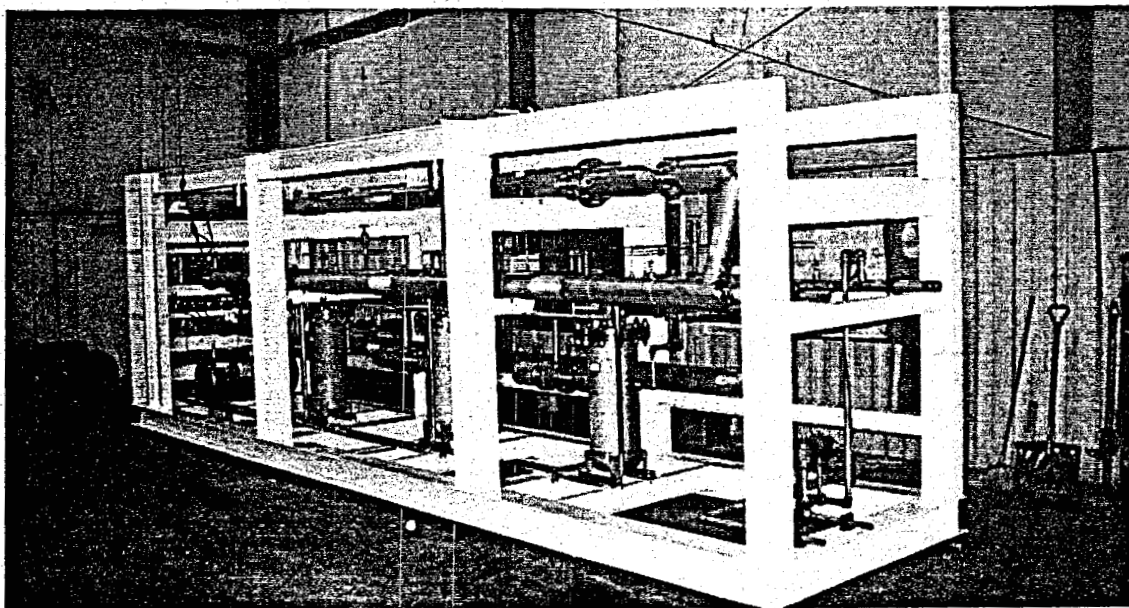
Three LNG dispenser manifolds were designed and fabricated for Lone Star. Mounted in a catwalk over the fueling lanes, these assemblies provide for improved appearance in the dispensing area as well as easy access for maintenance. The fueling hoses translate fore & aft to allow for various bus lengths.
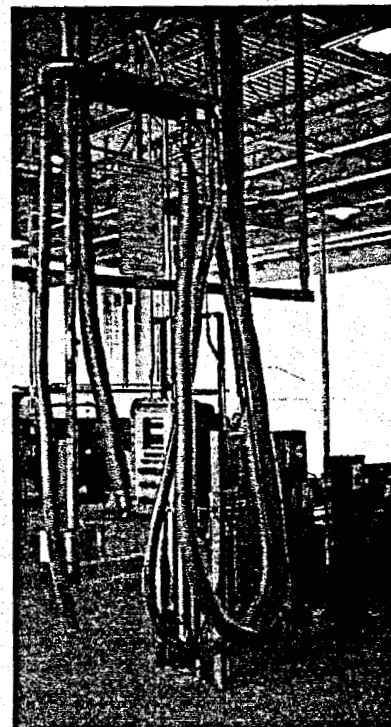
Dallas Area Rapid Transit
LNG Fueling Equipment (continued)

Dallas, Texas
January & December 1998

Design services for equipment layout and process piping were provided at both sites. The station at South Oak Cliff went into operation on May 16, 2000, and sets the LNG transit station standard for:

- ✓ Functionality
- ✓ Flexibility of Operation
- ✓ Safety Systems
- ✓ Control System Capability
- ✓ Appearance
- ✓ Ease of Maintenance
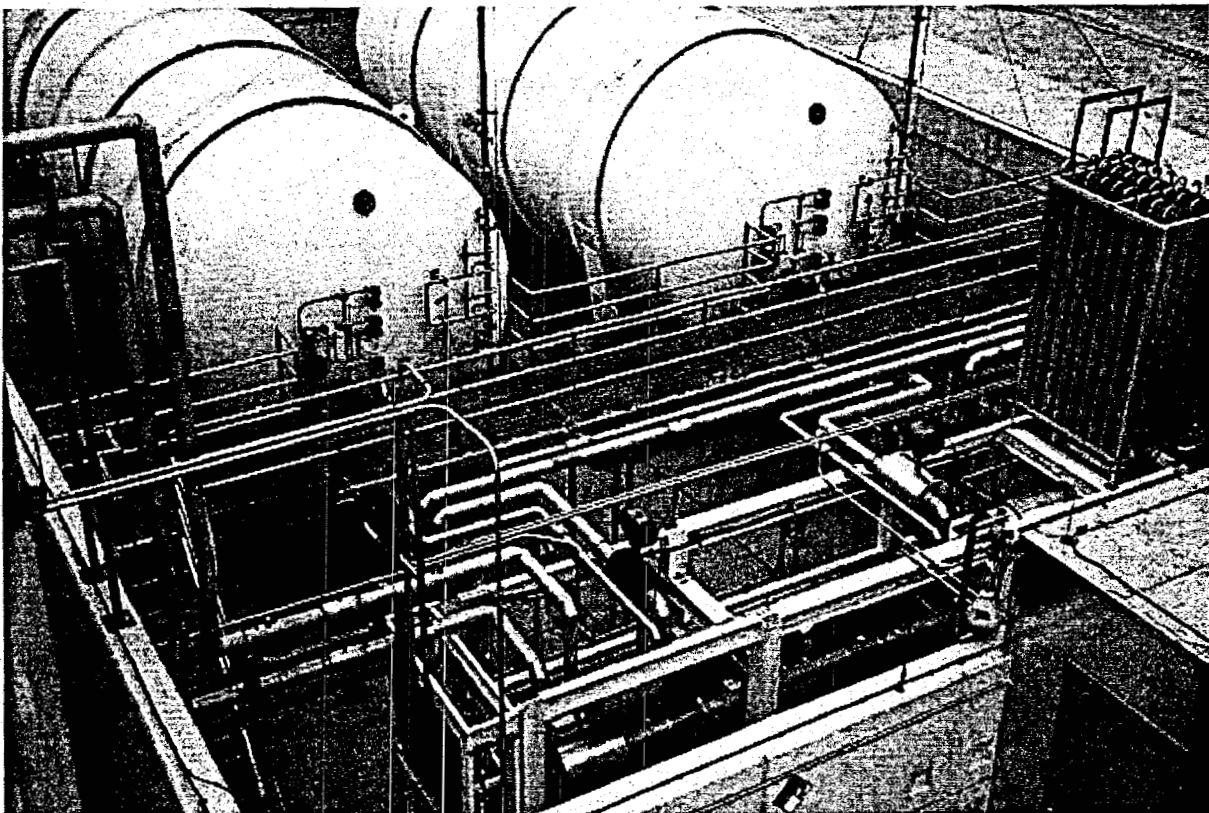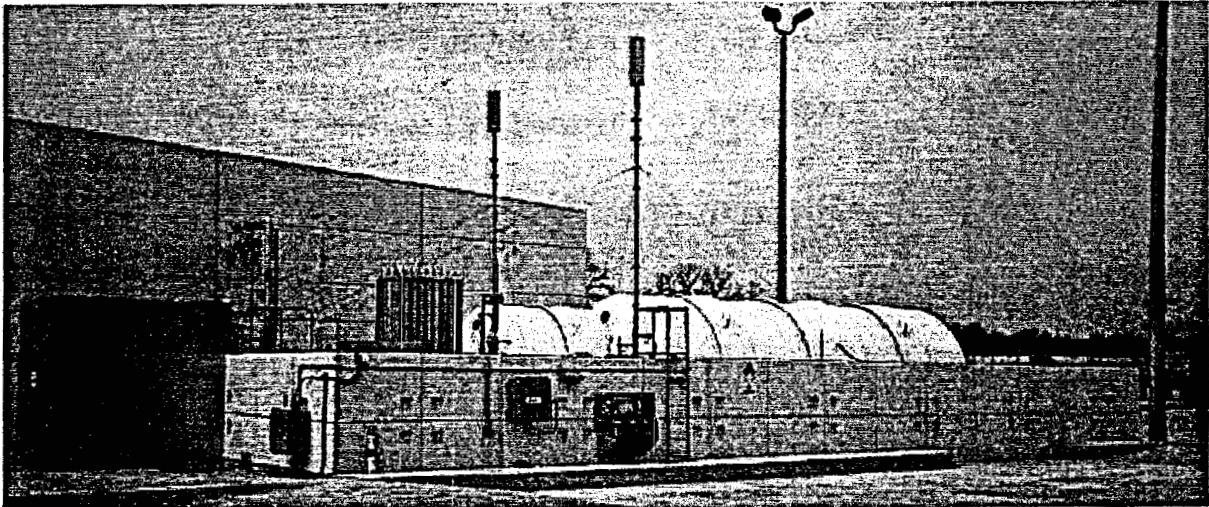
Attachment C
DFW LNG Tank Levels

LIQUID LEVEL CHART

STATIC HEAD (IN H2O)	LNG 0 PSIG (GALLONS)	LNG 20 PSIG (GALLONS)	LNG 40 PSIG (GALLONS)	LNG 60 PSIG (GALLONS)	LNG 80 PSIG (GALLONS)	LNG 100 PSIG (GALLONS)	LNG 120 PSIG (GALLONS)	LNG 140 PSIG (GALLONS)
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	12.4	12.4	17.4	17.4	17.4	0.0	0.0	0.0
1	42.2	42.2	49.5	49.5	49.5	17.4	17.4	17.4
1.5	82.3	82.3	91.3	91.3	91.3	49.5	49.5	57.2
2	120.2	130.4	140.9	140.9	151.6	100.7	100.7	100.7
2.5	173.9	185.4	197.1	197.1	209.1	151.6	151.6	162.6
3	233.7	246.3	259.1	272.2	272.2	209.1	205.4	221.2
3.5	298.9	312.5	326.4	340.4	354.6	285.4	285.4	298.9
4	354.6	383.6	398.4	413.3	428.4	354.6	369.0	383.6
4.5	428.4	459.2	474.6	490.5	506.5	443.7	443.7	459.2
5	506.5	530.8	555.1	571.7	588.3	522.5	538.8	555.1
5.5	571.7	622.1	639.2	673.8	691.3	605.2	622.1	639.2
6	656.5	709.0	726.7	762.7	780.8	709.0	726.7	744.6
6.5	744.6	780.6	817.5	854.6	873.3	799.1	817.5	854.6
7	836.0	873.3	911.1	949.4	988.1	911.1	930.2	949.4
7.5	911.1	968.7	1007.6	1046.9	1086.6	1007.6	1027.2	1066.7
8	1007.6	1066.7	1126.7	1167.1	1187.5	1126.7	1146.8	1167.1
8.5	1106.6	1167.1	1228.5	1269.9	1311.5	1228.5	1249.1	1290.7
9	1187.5	1269.9	1332.5	1374.7	1417.2	1332.5	1374.7	1417.2
9.5	1290.7	1374.7	1438.5	1481.5	1524.7	1460.0	1481.5	1524.7
10	1395.9	1481.5	1546.4	1590.1	1634.0	1568.2	1612.0	1656.0
10.5	1503.1	1590.1	1656.0	1700.3	1767.2	1678.1	1722.5	1767.2
11	1590.1	1700.3	1767.2	1834.5	1879.7	1812.0	1857.1	1902.4
11.5	1700.3	1812.0	1879.7	1947.9	1993.6	1925.1	1970.7	2039.5
12	1812.0	1925.1	1993.6	2062.5	2131.7	2062.5	2108.6	2154.9
12.5	1902.4	2016.5	2108.6	2178.1	2247.9	2178.1	2224.6	2294.7
13	2016.5	2131.7	2224.6	2294.7	2365.0	2316.1	2365.0	2412.1
13.5	2131.7	2247.9	2341.6	2435.7	2506.5	2435.7	2482.9	2553.9
14	2247.9	2365.0	2459.2	2553.9	2625.1	2553.9	2625.1	2672.6
14.5	2341.6	2482.9	2577.6	2672.6	2744.1	2696.4	2744.1	2815.7
15	2459.2	2601.3	2696.4	2791.8	2863.5	2815.7	2887.4	2959.1
15.5	2577.6	2720.3	2839.6	2911.3	3007.0	2959.1	3007.0	3078.8
16	2672.6	2839.6	2959.1	3054.9	3126.7	3078.8	3150.7	3222.5
16.5	2791.8	2959.1	3078.8	3174.6	3246.4	3198.6	3270.3	3342.1
17	2911.3	3078.8	3198.6	3294.3	3389.8	3342.1	3413.7	3485.2
17.5	3031.0	3198.6	3318.2	3413.7	3509.0	3461.4	3532.8	3627.8
18	3126.7	3318.2	3437.6	3532.8	3627.8	3580.3	3675.1	3746.0
18.5	3246.4	3437.6	3556.6	3651.5	3769.6	3722.4	3793.1	3887.0
19	3366.0	3532.8	3675.1	3793.1	3887.0	3840.1	3933.7	4003.6
19.5	3485.2	3651.5	3793.1	3910.4	4003.6	3980.3	4050.0	4142.3
20	3580.3	3769.6	3910.4	4026.8	4119.2	4096.2	4188.1	4279.3
20.5	3698.8	3887.0	4026.8	4142.3	4256.6	4211.0	4302.0	4392.2
21	3816.6	4003.6	4142.3	4256.6	4369.7	4347.2	4437.0	4525.8
21.5	3910.4	4119.2	4256.6	4392.2	4481.5	4459.3	4547.8	4635.4
22	4026.8	4233.8	4369.7	4503.7	4613.6	4591.8	4678.8	4764.7
22.5	4142.3	4347.2	4481.5	4613.6	4721.9	4700.4	4786.0	4891.2
23	4256.6	4459.3	4613.6	4721.9	4828.3	4807.2	4912.1	4994.4
23.5	4347.2	4569.8	4721.9	4828.3	4953.4	4932.8	5014.8	5115.3
24	4459.3	4678.8	4828.3	4953.4	5055.3	5035.1	5135.1	5213.4
24.5	4569.8	4786.0	4932.6	5055.3	5154.8	5154.8	5232.6	5327.5
25	4657.1	4870.4	5035.1	5154.8	5251.8	5251.8	5346.1	5419.5
25.5	4764.7	4974.0	5135.1	5251.8	5364.6	5364.6	5437.5	5525.7
26	4870.4	5075.4	5232.6	5346.1	5455.4	5455.4	5543.0	5627.1
26.5	4974.0	5174.4	5327.5	5437.5	5543.0	5543.8	5627.1	5707.6
27	5055.3	5270.9	5419.5	5543.8	5643.5	5723.2	5798.8	5870.0
27.5	5154.8	5364.4	5508.4	5627.1	5723.2	5813.4	5883.6	5949.0
28	5251.8	5455.4	5593.9	5707.6	5798.8	5883.6	5949.0	6020.1
28.5	5327.5	5543.0	5675.9	5784.0	5883.6	5949.0	6020.1	6072.5
29	5419.5	5627.1	5753.9	5856.1	5949.0	6020.1	6072.5	6125.8
29.5	5508.4	5707.6	5827.8	5936.8	6008.8	6072.5	6125.8	6160.3
30	5593.9	5784.0	5897.1	5997.3	6052.6	6125.8	6160.3	6183.7
30.5	5659.8	5856.1	5973.6	6052.4	6117.6	6160.3	6183.7	
31	5738.7	5923.5	6031.1	6100.6	6154.3	6182.0	6183.7	
31.5	5813.4	5973.6	6082.2	6140.8	6179.1	6183.7		
32	5870.0	6031.1	6125.8	6175.3	6183.7			
32.5	5936.3	6082.2	6160.3	6183.7				
33	5997.3	6125.8	6182.0					
33.5	6052.4	6160.3	6183.7					
34	6091.6	6182.0						
34.5	6133.5	6183.7						
35	6165.9							
35.5	6182.0							
36	6183.7							

C28M1532

FULL TRYCOCK = 5874.515 GALLONS

Attachment D
Schematic of the regulator system

From Pump

Exist. Direct Fill Vlv.

Exist Hose #1 Valve

Exist Hose #2 Valve

Exist. Pressure Vessel

Exist. Check Valves

New J-2 Filters w/ Drain Vlvs

New Dome Load Valve (Typ. 2)

New Tescom Adjustable Regulator

New 5000 PSI Pressure Gauge (Typ)

PG

PG

PG

PG

To Dispenser
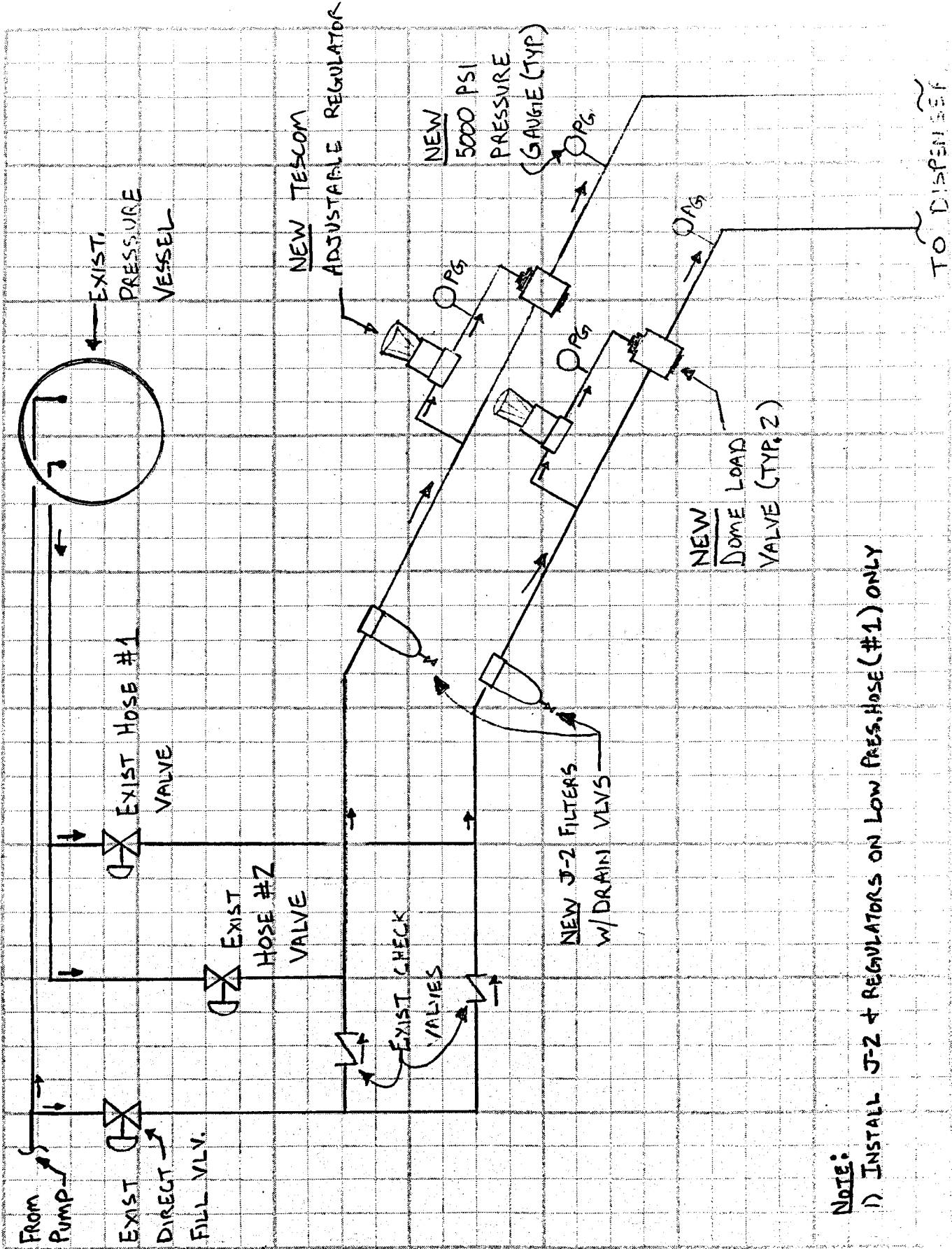
Note:
1) Install J-2 + Regulators on Low Pres. Hose (#1) only

Attachment E
Pump Criteria

ACD inc SEALESS PUMP
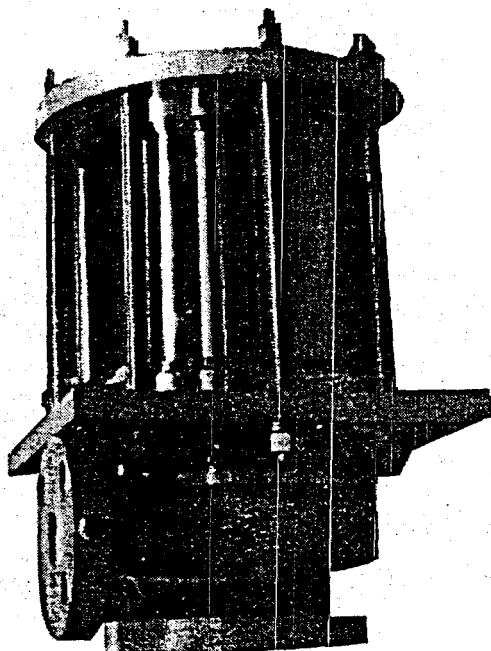
1 X 2 X 4.5
MODEL: AC-32

VARIABLE SPEED, CONTINUOUS DUTY PUMP

ACD, the leading worldwide supplier of cryogenic pumps, presents a reliable solution for LNG refueling applications. Featuring a sealess, leak-proof, variable speed, electric motor driven centrifugal pump. ACD's design incorporates more than 25 years experience in designing and building transfer pumps for LNG, LPG, liquified ammonia, oxygen, nitrogen and other cryogenic fluids.

The 1 x 2 x 4.5, AC-32 pump is hermetically sealed with an electric motor and centrifugal pump operating on a common shaft. No mechanical seal or other dynamic sealing device is used. Advance heat-transfer techniques allow the motor to be flooded with the fluid to be pumped. Another key feature is the bearings which are angular-contact/pre-loaded and are made of proprietary, chill-stabilized steel for reliable performance in harsh environments. These bearings have an exceptionally lightweight and strong retainer with a self-lubricating liner.

The pump is made from aluminum for durability and long life. The impeller is pressure balanced providing minimal axial thrust. A spiral type inducer is employed in the inlet to ensure proper fluid velocity distribution and boost for minimum NPSHR.

Specifications

Liquid Pumped:
- LNG

Flow Range
- 4-52 GPM

Differential Pressure Range
- 4-86 PSI

Maximum Casing Pressure
- 275 PSI

Operating Temperature Range
- -150°F to -280°F

Input Power
- 230 or 460 VAC, 3PH, 60Hz -Horse Power

Duty Rating
- Continuous operation or continuously flooded

LNG FILLING STATION PUMPS

Attachment F
MSDS Ethylene Glycol Antifreeze

Material Safety Data Sheet

Chevron Antifreeze

MSDS: 7425 Revision #: 2 Revision Date: 11/17/99

Click **Product Test Data** to search database.

---

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

CHEVRON Antifreeze   (EHL)

PRODUCT NUMBER(S): CPS698420

COMPANY IDENTIFICATION   EMERGENCY TELEPHONE NUMBERS

CHEVRON PRODUCTS COMPANY   HEALTH (24 hr): (800)231-0623 or
First Floor, 43/45 The Promenade   (510)231-0623 (International)
Cheltenham   TRANSPORTATION (24 hr): CHEMTREC
Gloucestershire, GL50 1LE   (800)424-9300 or (703)527-3887
United Kingdom   Emergency Information Centers
TELEPHONE: +44 (0) 1242 266700   are located in U.S.A.
                                       Int'l collect calls accepted

PRODUCT INFORMATION: CONTACT YOUR LOCAL SALES REPRESENTATIVE FOR TECHNICAL
                     INFORMATION OR ADDITIONAL MSDS REQUESTS.

---

2. COMPOSITION/INFORMATION ON INGREDIENTS

100.0 %   CHEVRON Antifreeze   (EHL)

  CONTAINING

COMPONENTS	AMOUNT	LIMIT/QTY	AGENCY/TYPE
ETHYLENE GLYCOL			
Chemical Name: ETHYLENE GLYCOL			
CAS107211	> 90.00%	C 50 ppm	ACGIH TWA
		125 mg/m3	OSHA CEILING
		5,000 LBS	CERCLA 302.4 RQ

COMPOSITION COMMENT:
All the components of this material are on the Toxic Substances Control
Act Chemical Substances Inventory.

---

3. HAZARDS IDENTIFICATION

*********************** EMERGENCY OVERVIEW ***********************

     Colorless (when not dyed).

- HARMFUL OR FATAL IF SWALLOWED
- MAY CAUSE RESPIRATORY TRACT IRRITATION IF INHALED
- POSSIBLE BIRTH DEFECT HAZARD - MAY CAUSE BIRTH DEFECTS
    BASED ON ANIMAL DATA

****

IMMEDIATE HEALTH EFFECTS
EYE:
Not expected to cause prolonged or significant eye irritation.
SKIN:
Contact with the skin is not expected to cause prolonged or significant
irritation. Not expected to be harmful to internal organs if absorbed
through the skin.
INGESTION:
Toxic; may be harmful or fatal if swallowed. See Section 11 for
additional information.
INHALATION:
The vapor or fumes from this material may cause respiratory irritation.
Breathing this material at concentrations above the recommended exposure
limit may cause central nervous system effects.
SIGNS AND SYMPTOMS OF EXPOSURE:
INGESTION: May result in nausea, vomiting, diarrhea, and in severe cases,
collapse, shock and death. Central nervous system effects may include
headache, dizziness, nausea, vomiting, weakness, loss of coordination,
blurred vision, drowsiness, confusion, or disorientation. At extreme
exposures, central nervous system effects may include respiratory
depression, tremors or convulsions, loss of consciousness, coma or death.
Respiratory irritation: may include coughing and difficulty breathing.
REPRODUCTION AND BIRTH DEFECTS:
Contains material that may cause birth defects, if swallowed, based on
animal data. Risk depends on duration and level of exposure. See Section
11 for additional information.
TARGET ORGANS:
Contains material that may cause damage to the following organ(s)
following repeated ingestion: >Kidney< >Liver< Risk depends on duration
and level of exposure. See Section 11 for additional information.

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4. FIRST AID MEASURES

EYE:
No specific first aid measures are required because this material is not
expected to cause eye irritation. As a precaution remove contact lenses,
if worn, and flush eyes with water.
SKIN:
No specific first aid measures are required because this material is not
expected to be harmful if it contacts the skin. As a precaution, remove
clothing and shoes if contaminated. Wash skin with soap and water. Wash
or clean contaminated clothing and shoes before reuse.
INGESTION:
If swallowed, do not induce vomiting. Give the person a glass of water or
milk to drink and get immediate medical attention. Never give anything by
mouth to an unconscious person.
INHALATION:
Move the exposed person to fresh air. If not breathing, give artificial
respiration. If breathing is difficult, give oxygen. Get medical
attention if breathing difficulties continue.

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5. FIRE FIGHTING MEASURES

FIRE CLASSIFICATION:
Classification (29 CFR 1910.1200): Not classified by OSHA as flammable or combustible.
FLAMMABLE PROPERTIES:
FLASH POINT: 257F (125C)
AUTOIGNITION: NDA
FLAMMABILITY LIMITS (% by volume in air): Lower: 3.2 Upper: 15.3
EXTINGUISHING MEDIA:
    CO2, Dry Chemical, Foam and Water Fog.
NFPA RATINGS: Health 2; Flammability 1; Reactivity 0.
FIRE FIGHTING INSTRUCTIONS:
This material will burn although it is not easily ignited. For fires involving this material, do not enter any enclosed or confined fire space without proper protective equipment, including self-contained breathing apparatus.
COMBUSTION PRODUCTS:
Normal combustion forms carbon dioxide and water vapor; incomplete combustion can produce carbon monoxide.

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6. ACCIDENTAL RELEASE MEASURES

CHEMTREC EMERGENCY NUMBER (24 hr): (800)424-9300 or (703)527-3887
    International Collect Calls Accepted
ACCIDENTAL RELEASE MEASURES:
Stop the source of the leak or release. Clean up releases as soon as possible, observing precautions in Exposure Controls/Personal Protection. Contain liquid to prevent further contamination of soil, surface water or groundwater. Clean up small spills using appropriate techniques such as sorbent materials or pumping. Where feasible and appropriate, remove contaminated soil. Follow prescribed procedures for reporting and responding to larger releases.

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7. HANDLING AND STORAGE

Container is not designed to contain pressure. Do not use pressure to empty container or it may rupture with explosive force. Empty containers retain product residue (solid, liquid, and/or vapor) and can be dangerous. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, static electricity, or other sources of ignition. They may explode and cause injury or death. Empty containers should be completely drained, properly closed, and promptly returned to a drum reconditioner, or properly disposed of. Wash thoroughly after handling. Do not taste or swallow. Do not breathe vapor or fumes.

---

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

GENERAL CONSIDERATIONS:
Consider the potential hazards of this material (see Section 3), applicable exposure limits, job activities, and other substances in the work place when designing engineering controls and selecting personal protective equipment. If engineering controls or work practices are not adequate to prevent exposure to harmful levels of this material, the personal protective equipment listed below is recommended. The user should read and understand all instructions and limitations supplied with the equipment since protection is usually provided for a limited time or under certain circumstances.

ENGINEERING CONTROLS

Use process enclosures, local exhaust ventilation, or other engineering
controls to control airborne levels below the recommended exposure limits.

PERSONAL PROTECTIVE EQUIPMENT
EYE/FACE PROTECTION:
No special eye protection is normally required. Where splashing is
possible, wear safety glasses with side shields as a good safety practice.
SKIN PROTECTION:
No special protective clothing is normally required. Where splashing is
possible, select protective clothing depending on operations conducted,
physical requirements and other substances. Suggested materials for
protective gloves include: <Natural Rubber> <Nitrile> <Polyvinyl Chloride
(Also referred to as "Vinyl" or "PVC")>
RESPIRATORY PROTECTION:
Determine if airborne concentrations are below the recommended exposure
limits. If not, wear a NIOSH approved respirator that provides adequate
protection from measured concentrations of this material. Use the
following respirators: Organic vapor plus dust mask filter. Use a
positive pressure, air-supplying respirator if there is potential for
uncontrolled release, exposure levels are not known, or other
circumstances where air-purifying respirators may not provide adequate
protection.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION:
   Colorless (when not dyed).
pH: NDA
VAPOR PRESSURE: NA
VAPOR DENSITY
   (AIR=1):   NA
BOILING POINT: >165C
FREEZING POINT: NDA
MELTING POINT: NA
SOLUBILITY: Soluble in water.
SPECIFIC GRAVITY: NDA
DENSITY: NDA
VISCOSITY: 21 @ 20C cPs

10. STABILITY AND REACTIVITY

HAZARDOUS DECOMPOSITION PRODUCTS:
No data available.
CHEMICAL STABILITY:
Stable.
CONDITIONS TO AVOID:
No data available.
INCOMPATIBILITY WITH OTHER MATERIALS:
No data available.
HAZARDOUS POLYMERIZATION:
Polymerization will not occur.

11. TOXICOLOGICAL INFORMATION

EYE EFFECTS:
The eye irritation hazard is based on an evaluation of the data for the
components.
SKIN EFFECTS:

The skin irritation hazard is based on an evaluation of the data for the
components.
ACUTE ORAL EFFECTS:
The acute oral toxicity is based on an evaluation of the data for the
components.
ACUTE INHALATION EFFECTS:
The acute respiratory toxicity is based on an evaluation of the data for
the components.
ADDITIONAL TOXICOLOGY INFORMATION:
This product contains ethylene glycol (EG). The toxicity of EG via
inhalation or skin contact is expected to be slight at room temperature.
The estimated oral lethal dose is about 100 cc (3.3 oz.) for an adult
human. Ethylene glycol is oxidized to oxalic acid which results in the
deposition of calcium oxalate crystals mainly in the brain and kidneys.
Early signs and symptoms of EG poisoning may resemble those of alcohol
intoxication. Later, the victim may experience nausea, vomiting, weakness,
abdominal and muscle pain, difficulty in breathing and decreased urine
output. When EG was heated above the boiling point of water, vapors
formed which reportedly caused unconsciousness, increased lymphocyte
count, and a rapid, jerky movement of the eyes in persons chronically
exposed. When EG was administered orally to pregnant rats and mice, there
was an increase in fetal deaths and birth defects. Some of these effects
occurred at doses that had no toxic effects on the mothers. We are not
aware of any reports that EG causes reproductive toxicity in human beings.

12. ECOLOGICAL INFORMATION

ECOTOXICITY:
No data available.
ENVIRONMENTAL FATE:
This material is expected to be readily biodegradable.

13. DISPOSAL CONSIDERATIONS

Place contaminated materials in disposable containers and dispose of in a
manner consistent with applicable regulations. Contact local
environmental or health authorities for approved disposal of this
material.

14. TRANSPORT INFORMATION

The description shown may not apply to all shipping situations.
Consult 49CFR, or appropriate Dangerous Goods Regulations, for
additional description requirements (e.g., technical name) and
mode-specific or quantity-specific shipping requirements.

DOT SHIPPING NAME: NONE
DOT HAZARD CLASS: NONE
DOT IDENTIFICATION NUMBER: NONE
DOT PACKING GROUP: N/A
ADDITIONAL INFO: ETHYLENE GLYCOL - - NOT HAZARDOUS BY U.S. DOT
                ADR/RID HAZARD CLASS - NOT APPLICABLE

15. REGULATORY INFORMATION

```
SARA 311 CATEGORIES:        1.  Immediate (Acute) Health Effects:  YES
                            2.  Delayed (Chronic) Health Effects:  YES
                            3.  Fire Hazard:                        NO
                            4.  Sudden Release of Pressure Hazard:  NO
                            5.  Reactivity Hazard:                  NO
```

REGULATORY LISTS SEARCHED:

```
01=SARA 313              11=NJ RTK                 22=TSCA Sect 5(a)(2)
02=MASS RTK              12=CERCLA 302.4           23=TSCA Sect 6
03=NTP Carcinogen        13=MN RTK                 24=TSCA Sect 12(b)
04=CA Prop 65-Carcin     14=ACGIH TWA              25=TSCA Sect 8(a)
05=CA Prop 65-Repro Tox  15=ACGIH STEL             26=TSCA Sect 8(d)
06=IARC Group 1          16=ACGIH Calc TLV         27=TSCA Sect 4(a)
07=IARC Group 2A         17=OSHA PEL               28=Canadian WHMIS
08=IARC Group 2B         18=DOT Marine Pollutant   29=OSHA CEILING
09=SARA 302/304          19=Chevron TWA            30=Chevron STEL
10=PA RTK                20=EPA Carcinogen
```

The following components of this material are found on the regulatory
lists indicated.

ETHYLENE GLYCOL
     is found on lists: 01,02,10,11,12,13,14,28,29,

EU RISK AND SAFETY LABEL PHRASES:
R22: Harmful if swallowed.
R20: Harmful by inhalation.
R61: May cause harm to the unborn child.
S53: Avoid exposure - obtain special instructions before use.
S20: When using do not eat or drink.
S46: If swallowed, seek medical advice immediately and show this
container or label.
S2: Keep out of reach of children.
WHMIS CLASSIFICATION:
Class D, Division 1, Subdivision B: Toxic Material
-Acute Lethality
Class D, Division 2, Subdivision A: Very Toxic Material
-Teratogenicity and Embryotoxicity

---

16. OTHER INFORMATION

NFPA RATINGS: Health 2; Flammability 1; Reactivity 0;
HMIS RATINGS: Health 2*; Flammability 1; Reactivity 0;
(0-Least, 1-Slight, 2-Moderate, 3-High, 4-Extreme, PPE:- Personal
Protection Equipment Index recommendation, *- Chronic Effect
Indicator). These values are obtained using the guidelines or
published evaluations prepared by the National Fire Protection
Association (NFPA) or the National Paint and Coating Association
(for HMIS ratings).

REVISION STATEMENT:
This revision updated Sections 3, and 15.

ABBREVIATIONS THAT MAY HAVE BEEN USED IN THIS DOCUMENT:
TLV - Threshold Limit Value   TWA - Time Weighted Average
STEL - Short-term Exposure Limit   TPQ - Threshold Planning Quantity
RQ   - Reportable Quantity   PEL - Permissible Exposure Limit
C   - Ceiling Limit   CAS - Chemical Abstract Service Number
A1-5 - Appendix A Categories   () - Change Has Been Proposed
NDA - No Data Available   NA - Not Applicable

Prepared according to the OSHA Hazard Communication Standard
(29 CFR 1910.1200) and the ANSI MSDS Standard (Z400.1) by the Toxicology
and Health Risk Assessment Unit, CRTC, P.O. Box 1627, Richmond, CA 94804

****

The above information is based on the data of which we are aware and is
believed to be correct as of the date hereof. Since this information may
be applied under conditions beyond our control and with which we may be
unfamiliar and since data made available subsequent to the date hereof may
suggest modification of the information, we do not assume any responsibil-
ity for the results of its use. This information is furnished upon
condition that the person receiving it shall make his own determination
of the suitability of the material for his particular purpose.

****
                    THIS IS THE LAST PAGE OF THIS MSDS
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Attachment G
MSDS LNG

MATERIAL SAFETY DATA SHEET

MSDS No. 10858000
ENGLISH

1.0 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: LIQUIFIED NATURAL GAS (LNG)

MANUFACTURER/SUPPLIER:
Amoco Oil Company
200 East Randolph Drive
Chicago, Illinois 60601 U.S.A.

EMERGENCY HEALTH INFORMATION:
1 (800) 447-8735
EMERGENCY SPILL INFORMATION:
1 (800) 424-9300 CHEMTREC (USA)
OTHER PRODUCT SAFETY INFORMATION:
(312) 856-3907

2.0 COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS#	Range % by Wt.
Methane	74-82-8	95-100
Ethane	74-84-0	<2

(See Section 8.0, "Exposure Controls/Personal Protection", for exposure guidelines)

3.0 HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Danger! Extremely flammable. Compressed gas. At very high concentrations, can displace the normal air and cause suffocation from lack of oxygen. Liquid can cause burns similar to frostbite.

POTENTIAL HEALTH EFFECTS:

EYE CONTACT: Extremely cold material; can cause burns similar to frostbite.

SKIN CONTACT: Liquid can cause burns similar to frostbite.

INHALATION: At very high concentrations, can displace the normal air and cause suffocation from lack of oxygen. See "Toxicological Information" section (Section 11.0).

INGESTION: Ingestion of liquid can cause burns similar to frostbite.

HMIS CODE: (Health:1) (Flammability:4) (Reactivity:0)

NFPA CODE: (Health:1) (Flammability:4) (Reactivity:0)

Issued: September 19, 1995

4.0 FIRST AID MEASURES

EYE: Contact with liquid: Immediately flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

SKIN: Contact with liquid: Immediately flush with plenty of tepid water (105-115°F; 41-46°C). DO NOT USE HOT WATER. Get immediate medical attention.

INHALATION: If adverse effects occur, immediately remove to uncontaminated area. Give artificial respiration if not breathing. Give oxygen if breathing is difficult. Get immediate medical attention.

INGESTION: Get immediate medical attention.

5.0 FIRE FIGHTING MEASURES

FLASHPOINT: -306°F(-188°C) (closed cup)

UEL: Not determined.

LEL: Not determined.

AUTOIGNITION TEMPERATURE: Not determined.

FLAMMABILITY CLASSIFICATION: Extremely flammable. Compressed gas.

EXTINGUISHING MEDIA: Stop flow of gas if possible; if not, allow to burn. Do NOT direct water into liquid spill. Dry chemical can be used.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Product gives off vapors that are heavier than air which can travel considerable distances to a source of ignition and flashback. Extinguishment of fire before source of vapor is shut off can create an explosive mixture in air. Extremely flammable vapor/air mixtures form.

FIRE-FIGHTING EQUIPMENT: Firefighters should wear full bunker gear, including a positive pressure self-contained breathing apparatus.

PRECAUTIONS: Keep away from sources of ignition (e.g., heat and open flames). Use with adequate ventilation.

HAZARDOUS COMBUSTION PRODUCTS: Burning can produce carbon monoxide and/or carbon dioxide and other harmful products.

6.0 ACCIDENTAL RELEASE MEASURES

Remove or shut off all sources of ignition. Wear respirator and spray with water to disperse vapors.

7.0 HANDLING AND STORAGE

HANDLING: Do not breathe vapors. Ground and bond all lines and equipment.

STORAGE: Outside storage is recommended. Store in cool, dry, well-ventilated area. Do not store in areas containing flammable or combustible products. Do not store at or above 120°F (49°C). Store away from heat, ignition sources, and open flame in accordance with applicable regulations.

SPECIAL PRECAUTIONS: Avoid strong oxidizers.

Issued: September 19, 1995

8.0   EXPOSURE CONTROLS / PERSONAL PROTECTION

EYE: Do not get in eyes. Wear chemical goggles.

SKIN: As needed to prevent contact with liquid - wear gloves, impervious clothing and face shield.

INHALATION: If ventilation is inadequate, use supplied- air respirator approved by NIOSH/MSHA.

ENGINEERING CONTROLS: Control airborne concentrations below the exposure guidelines.

EXPOSURE GUIDELINES:

Component	CAS#	Exposure Limits
Methane	74-82-8	ACGIH TLV-TWA: simple asphyxiant
Ethane	74-84-0	ACGIH TLV-TWA: simple asphyxiant

9.0   CHEMICAL AND PHYSICAL PROPERTIES

APPEARANCE AND ODOR:	Gas. Colorless.
pH:	Not determined.
VAPOR PRESSURE:	Not determined.
VAPOR DENSITY:	Not determined.
BOILING POINT:	-260°F(-162°C) (approximate)
MELTING POINT:	-297°F(-183°C) (approximate)
SOLUBILITY IN WATER:	Negligible, below 0.1%.
SPECIFIC GRAVITY (WATER=1):	Not determined.

10.0   STABILITY AND REACTIVITY

STABILITY: Burning can be started easily.

CONDITIONS TO AVOID: Keep away from ignition sources (e.g. heat, sparks, and open flames).

MATERIALS TO AVOID: Avoid chlorine, fluorine, and other strong oxidizers.

HAZARDOUS DECOMPOSITION: None identified.

HAZARDOUS POLYMERIZATION: Will not occur.

11.0   TOXICOLOGICAL INFORMATION

ACUTE TOXICITY DATA:

   EYE IRRITATION: Testing not conducted. See Other Toxicity Data.

   SKIN IRRITATION: Testing not conducted. See Other Toxicity Data.

   DERMAL LD50: Testing not conducted. See Other Toxicity Data.

ORAL LD50: Testing not conducted. See Other Toxicity Data.

INHALATION LC50: Testing not conducted. See Other Toxicity Data.

OTHER TOXICITY DATA:

This material is an asphyxiant. Asphyxiants may reduce the oxygen concentration in the air to dangerous levels. Symptoms of lack of oxygen include increased depth and frequency of breathing, air hunger, dizziness, headache, nausea or loss of consciousness.

No component of this product at levels greater than 0.1% is identified as a carcinogen by ACGIH or the International Agency for Research on Cancer (IARC). No component of this product present at levels greater than 0.1% is identified as a carcinogen by the U.S. National Toxicology Program (NTP) or the U.S. Occupational Safety and Health Act (OSHA).

12.0   ECOLOGICAL INFORMATION

Ecological testing has not been conducted on this product.

13.0   DISPOSAL INFORMATION

Vent vapor at a safe location. Insure dissipation of gas below the lower explosive limit. Consult local ordinances for compliance.

14.0   TRANSPORTATION INFORMATION

U.S. DEPT OF TRANSPORTATION

Shipping Name	:	Natural Gas, Refrigerated Liquid
Hazard Class	:	2.1
Identification Number	:	UN1972

INTERNATIONAL INFORMATION:

Sea (IMO/IMDG)
    Shipping Name   :   Not determined.

Air (ICAO/IATA)
    Shipping Name   :   Not determined.

European Road/Rail (ADR/RID)
    Shipping Name   :   Not determined.

Canadian Transportation of Dangerous Goods
    Shipping Name   :   Not determined.

15.0   REGULATORY INFORMATION

CERCLA SECTIONS 102A/103 HAZARDOUS SUBSTANCES (40 CFR PART 302.4): This product is not reportable under 40 CFR Part 302.4.

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR PART 355): This product is not regulated under Section 302 of SARA and 40 CFR Part 355.

SARA TITLE III SECTIONS 311/312 HAZARDOUS CATEGORIZATION (40 CFR PART 370): This product is defined as hazardous by OSHA under 29 CFR Part 1910.1200(d).

SARA TITLE III SECTION 313 (40 CFR PART 372): This product is not regulated under Section 313 of SARA and 40 CFR Part 372.

U.S. INVENTORY (TSCA):   Listed on inventory.

OSHA HAZARD COMMUNICATION STANDARD: Flammable gas. Compressed gas. Contains a component listed by OSHA. Contains a component listed by ACGIH.

WHMIS CONTROLLED PRODUCT CLASSIFICATION: A, B1,

EC INVENTORY (EINECS/ELINCS):   In compliance.

JAPAN INVENTORY (MITI):   Listed on inventory.

AUSTRALIA INVENTORY (AICS):   Listed on inventory.

KOREA INVENTORY (ECL):   Not determined.

CANADA INVENTORY (DSL):   All of the components of this product are listed on the DSL.

PHILIPPINE INVENTORY (PICCS):   Not determined.

16.0   OTHER INFORMATION

Prepared by:

Environment, Health and Safety Department

Issued: September 19, 1995
Supersedes: October 25, 1994

This material Safety Data Sheet conforms to the requirements of ANSI Z400.1.

This material safety data sheet and the information it contains is offered to you in good faith as accurate. We have reviewed any information contained in this data sheet which we received from sources outside our company. We believe that information to be correct but cannot guarantee its accuracy or completeness. Health and safety precautions in this data sheet may not be adequate for all individuals and/or situations. It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. No statement made in this data sheet shall be construed as a permission or recommendation for the use of any product in a manner that might infringe existing patents. No warranty is made, either express or implied.

Attachment H
MSDS Natural Gas

MATERIAL SAFETY DATA SHEET

SECTION I - Identification

Material Name: Natural Gas

Description: Fuel gas delivered in pipelines

Other Designations: Methane or other appropriate term

Supplier: Lone Star Gas Company

SECTION II - Ingredients

(1) Natural gas may vary considerably in its composition. It is principally methane (typically 80% or more) with decreasing concentrations of the higher saturated hydrocarbons. Natural gas may also contain natural occurring noncombustible gases such as nitrogen, carbon dioxide and helium.

SECTION III - Physical Data

Relative Density of Natural Gas: 0.55 to 0.S0 (Air = 1.0) at 14.65 psia and 60°F

Appearance: Colorless and tasteless

Odor: Odorless in the natural state. However, federal and state regulations require the addition of a malodorant to make the gas readily detectable at a concentration of at least 20% of the lower flammable limit in air as a warning agent. A trace of mercaptans (less than 10 ppm) is added for this purpose.

SECTION IV - Fire and Explosion Data

Auto Ignition Temp.	Flammable Limits in Air*	Lower	Upper
900°F - 1200°F	% by Vol.	4.S	13.5

Ignition can occur between the lower and upper flammable limits which express percent of natural gas in the air. Natural gas without sufficient air or with too much air will not burn or explode.

*Marks Standard Handbook for Mechanical Engineers, Sth Edition

Extinguishing Media: Flame can be extinguished with CO_2, dry chemical, or halo carbon gas. A hazard from reignition or explosion exists if the flame is extinguished without stopping the flow of gas and/or cooling the surroundings and eliminating the ignition sources. Use water spray to cool surroundings and exposures.

SECTION V - Health Hazard Information

Natural gas is non-toxic; however, it acts as a simple asphyxiant by displacing or partially displacing the air required to support life.

First Aid: Remove victim to fresh air, and, if breathing has stopped, begin mouth-to-mouth resucitation and get medical aid.

SECTION VI - Reactivity Data

Natural gas is generally stable, non-corrosive and non-polymerizing, but readily mixes with air when released to create a combustible atmosphere. Some other strong oxidizing agents with which it can mix and burn or explode in confined areas are chlorine, bromine pentafluoride, oxygen difluoride and nitrogen trifluoride. It will ignite spontaneously when mixed with chlorine dioxide.

SECTION VII - Leaks and Disposal Procedures

Evacuate area, provide optimum explosion proof ventilation. Shut off supply, remove or eliminate ignition sources. Report leak to Lone Star Gas Company. Minor leaks can be detected with soap solution applied at suspected leak points. NEVER USE A FLAME TO DETECT LEAKS.

(1) NOTE: This sheet covers "Natural Gas" as a general commodity for employee "right to know" information only. The exact specifications will vary to some extent from area to area. If for reasons of process control, more specific data is required as to composition, pressure or other factors, the user must contact Lone Star Gas Company.

Attachment I
MSDS Mercaptan

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MSDS NUMBER :   M36045   ISSUE DATE :   01-01-98

PRODUCT NAME :   BP CAPTAN

Manufacturer's   Natural Gas Odorizing, Inc
Name and   3601 Decker Drive, P.O. Box 1429
Address :   Baytown, TX   77522-1429

24 HOUR EMERGENCY TELEPHONE :   1-800-733-3665 OR   972-404-3228

TO REQUEST AN MSDS :   1-800-699-4970

CUSTOMER SERVICE :   1-281-424-5568

PRODUCT USE :   Natural Gas Odorizer

CHEMICAL NAME : Mixture

CHEMICAL FORMULA : Complex Mixture

SYNONYMS/COMMON NAMES : Mercaptan

2. COMPOSITION/INFORMATION ON INGREDIENTS

CAS NUMBER / NAME
75-66-1   2-Propanethiol, 2-methyl-

EXPOSURE LIMITS   PERCENTAGE
 PEL:Not Established   VOL   ND
 TLV:Not Established   WT   75-80

COMMON NAMES:
 tert-BUTYL MERCAPTAN

Listed On(List Legend Below):
 00 12 22 23 50 51
- -

2. COMPOSITION/INFORMATION ON INGREDIENTS (Continued)

75-33-2   2-Propanethiol

EXPOSURE LIMITS   PERCENTAGE
 PEL:Not Established   VOL   ND
 TLV:Not Established   WT   14-22

COMMON NAMES:
 ISOPROPANETHIOL
 ISOPROPYL MERCAPTAN

Listed On(List Legend Below):
 00 16 19 22 50 51
- -

107-03-9   1-Propanethiol

EXPOSURE LIMITS   PERCENTAGE
 PEL:Not Established   VOL   ND
 TLV:Not Established   WT   2-7

COMMON NAMES:
 NORMAL PROPYL MERCAPTAN

Listed On(List Legend Below):
 00 16 19 22 50 51
- -

513-53-1   2-Butanethiol

EXPOSURE LIMITS   PERCENTAGE
 PEL:Not Established   VOL   ND
 TLV:Not Established   WT   0-3

COMMON NAMES:
 SEC-BUTYL MERCAPTAN

Listed On(List Legend Below):
 00 12 22 23 51
- -

LIST LEGEND
00 TSCA INVENTORY   12 PA HAZARDOUS SUBSTANCE
16 NJ WORKPLACE HAZ SUBSTANCE LST   19 PA REQUIREMENT- 3% OR GREATER
22 CANADIAN DOMESTIC SUB LIST   23 NJ REQUIREMENT- 1% OR GREATER
50 PHILIPPINES INVENTORY (PICCS)   51 EINECS

3. HAZARDS IDENTIFICATION

********************** EMERGENCY OVERVIEW **************************

* FLAMMABLE LIQUID.

* Water white liquid, gassy odor

3. HAZARDS IDENTIFICATION (Continued)

POTENTIAL HEALTH EFFECTS

ROUTES OF ENTRY:

Eyes, Inhalation, Skin, Ingestion.

TARGET ORGANS:

Eyes, Skin, Central Nervous System, Respiratory Tract, Kidneys.

IRRITANCY:

All routes of exposure.

SENSITIZING CAPABILITY:

None known.

REPRODUCTIVE EFFECTS:

None known.

CANCER INFORMATION:

Not known to be carcinogenic.

SHORT-TERM EXPOSURE (ACUTE)

INHALATION:

Vapor and/or mist may cause upper respiratory tract irritation, nausea, and dizziness depending on concentration and duration of exposure.

EYES:

May be irritating.

SKIN:

May be irritating.

INGESTION:

May be irritating to the gastrointestinal tract.

May be harmful by ingestion.

REPEATED EXPOSURE (CHRONIC)

See Toxicology Section of the MSDS (Section 11).

SYNERGISTIC MATERIALS:

None known.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:

None known.

4. FIRST AID MEASURES

EYES:

IMMEDIATELY flush eyes with a directed stream of water for at least 15 minutes, forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue. IF IRRITATION PERSISTS GET MEDICAL ATTENTION.

SKIN:

Wash thoroughly with soap and water. Wash clothing before reuse. IF IRRITATION OCCURS, GET MEDICAL ATTENTION.

INHALATION:

Remove to fresh air. If breathing is difficult, have trained person administer oxygen. If respiration stops, have a trained person administer artificial respiration. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:

DO NOT INDUCE VOMITING. This material is not soluble. DO NOT GIVE FLUIDS. If spontaneous vomiting is inevitable, PREVENT ASPIRATION by keeping the victims head below the knees. GET IMMEDIATE MEDICAL ATTENTION. A qualified physician can perform gastric lavage only when the airway (trachea) has been secured to prevent aspiration.

NOTES TO PHYSICIAN:

None known.

5. FIRE FIGHTING MEASURES

Flash Point: -16°F (-26.7°C)

Method: Setaflash

Autoignition Temperature: Not Established

FLAMMABLE LIMITS IN AIR, BY % VOLUME

Upper: 10% (estimate)
Lower: 1.7% (estimate)

EXTINGUISHING MEDIA:

Dry chemical, carbon dioxide, foam, water fog or spray. Water may be ineffective, but should be used to keep fire-exposed containers cool.

FIRE FIGHTING PROCEDURES:

Evacuate all unnecessary personnel. Shut down motors, pumps, electrical service and eliminate all sources of ignition. Use water spray to keep fire exposed containers cool to avoid pressure buildup. Wear NIOSH/MSHA approved positive pressure self-contained breathing apparatus and full protective clothing.

5. FIRE FIGHTING MEASURES (Continued)

FIRE AND EXPLOSION HAZARD:

Flammable vapors, being heavier than air, may travel long distances along the ground before reaching a source of ignition and flashing back.

SENSITIVITY TO MECHANICAL IMPACT:

Not sensitive.

SENSITIVITY TO STATIC DISCHARGE:

Electrostatic charge may build up during handling. Grounding of equipment is recommended.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS:

Evacuate unnecessary personnel and eliminate all sources of ignition.

People performing the cleanup should have full protective equipment including a NIOSH/MSHA approved positive pressure self-contained breathing apparatus.

Wear personal protective equipment as described in Exposure Controls/Personal Protection (Section 8) of the MSDS.

ENVIRONMENTAL PRECAUTIONS:

Contain liquids and prevent discharges to streams or sewers, control or stop the loss of volatile materials to the atmosphere. Large leaks may require environmental consideration and possible evacuation. Do not apply water to the leak. Spills or releases should be reported, if required, to the appropriate local, state and federal agencies.

METHODS FOR CLEANING UP:

Shut off all sources of potential sparking or open flame.

Absorb in dry, inert material (sand, clay, sawdust).

Avoid discharges to sewers and streams.

7. HANDLING AND STORAGE

HANDLING:

Avoid breathing vapor, use with adequate ventilation. Wear NIOSH/MSHA approved respiratory protection if there is potential for exposure above the exposure limits.

Do not get in eyes, on skin or clothing.

7. HANDLING AND STORAGE (Continued)

Keep away from sources of ignition. The vapors can travel to an
ignition source and flash back causing a flash fire.

SPECIAL MIXING AND HANDLING INSTRUCTIONS:

Keep container closed except when transferring material.

Use with adequate ventilation.

Do not reuse containers. Toxic and explosive product residues may
remain in containers.

STORAGE:

Store in a cool, dry, ventilated area away from heat, sparks and
flame.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS:

Use vapor and explosion proof equipment.

PERSONAL PROTECTION

RESPIRATORY:

For emergencies and unknown concentrations, use NIOSH/MSHA approved
positive pressure self-contained breathing apparatus. Utilize
respiratory protective equipment in accordance with 29CFR 1910.134
(Respiratory Protection).

EYE/FACE:

Wear chemical safety goggles plus full face shield to protect against
splashing when appropriate (ANSI Z87.1).

SKIN:

Wear chemical resistant gloves such as rubber, neoprene or
vinyl.

OTHER:

Emergency shower and eyewash facility should be in close proximity
(ANSI Z358.1).

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Water white liquid, gassy odor

Odor Threshold: 2-methyl-2-propane thiol=0.008 ppb, 2-propane-
                thiol = 0.024 ppb

Specific Gravity (Water=1): 0.808 @ 60°F

9. PHYSICAL AND CHEMICAL PROPERTIES (Continued)

Vapor Pressure: 6.4 psia @ 100°F

Vapor Density (Air=1): 3.0

Density: 6.73 lbs. gal. @ 60°F

Evaporation Rate: Not Determined

% Volatiles by Wt: 100

Boiling Point: 138° - 155°F

Freezing Point: <-50°F

Melting Point: Not Determined

Solubility in Water (% by wt.): Negligible

pH: Not Determined

Octanol/Water Partition Coefficient: Not Determined

Thermal Decomposition Temperature: Not Determined

Other: Corrosion-Copper strip (24 hr. immersion test)
       negligible

VOC (g/l. by wt.): Not Determined

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY:

        X   STABLE   _____ UNSTABLE

REACTS WITH:

        _____ AIR   X   OXIDIZERS   _____ METALS
        _____ WATER   _____ ACIDS   _____ OTHER
        X   HEAT   _____ ALKALIS   _____ NONE

HAZARDOUS POLYMERIZATION:

        _____ OCCURS   X   WILL NOT OCCUR

COMMENTS:
None.

HAZARDOUS DECOMPOSITION PRODUCTS:
Hydrogen sulfide.

Products of combustion include sulfur dioxide.

11. TOXICOLOGICAL INFORMATION

75-66-1   2-Propanethiol, 2-methyl-

ACUTE ORAL LD50 :	(rat)	4729 mg/kg
ACUTE DERMAL LD50 :	(rabbit)	20.8 g/kg
ACUTE INHALATION LC50 :	(rat, 4 hr)	22,200 ppm
PRIMARY EYE IRRITATION:	(rabbit)	slight

Inflammatory lesions in the lungs were seen in subchronic tests in
rats, Also seen was muscle weakness, lung and thorax effects and
respiratory depresson.

A subchronic (90) day inhalation study with tertiary butyl mercaptan
in rats resulted in mild kidney effects (proximal tubular nephrosis)
at concentrations from 10 ppm to 200 ppm.

75-33-2   2-Propanethiol

ACUTE ORAL LD50 :	(rat)	>2000 mg/kg >5000 mg/kg
ACUTE INHALATION LC50 :	(rat)	>5917 ppm (4 hr)

107-03-9   1-Propanethiol

ACUTE ORAL LD50 :	(rat)	1790 mg/kg
ACUTE INHALATION LC50 :	(rat, 4hr) (mouse, 4hr)	7300 ppm 4010 ppm
PRIMARY EYE IRRITATION :	(rabbit)	severe

12. ECOLOGICAL INFORMATION

75-66-1   2-Propanethiol, 2-methyl-

AQUATIC ECOTOX DATA
          No data available

TERRESTRIAL ECOTOX DATA
Wildlife:

LC50 (inhal.)	(Mouse as surrogate)	16,500 ppm/4hr
LD50 (oral)	(Rat as surrogate)	4,729 mg/Kg

ENVIRONMENTAL FATE DATA
          No data available

There is very limited information available on the environmental fate
and effects of this material. This compound has been found to exhibit
low toxicity to rodents. Due caution should be exercised to avoid the
accidental release of this material to aquatic or terrestrial
environments.

12. ECOLOGICAL INFORMATION (Continued)

75-33-2   2-Propanethiol

AQUATIC ECOTOX DATA
Fish:
BCF   estimates based on Kow are 5.9 and 8.3

TERRESTRIAL ECOTOX DATA
                No data available

ENVIRONMENTAL FATE DATA
Abiotic:
Air (1/2 Life) estimate based on OH radical reaction is 9 hours.

Water (1/2 Life) estimate based on volatilization from river is 2.7 hrs

Water (1/2 Life) estimate based on volatilization from pond is 32 hrs.

There is very limited information available on the environmental fate
and effects of this material. This gaseous material occurs in nature
as a byproduct of biological activity. Models predict low potential
for bioaccumulation. Due caution should be exercised to avoid the
accidental release of this material to aquatic or terrestrial
environments.

107-03-9   1-Propanethiol

AQUATIC ECOTOX DATA
Fish:
BCF   model estimate based on Kow is 12

Invertebrate:
LC50 (96 hr)   (Water flea - magna)   60   ug/L

TERRESTRIAL ECOTOX DATA
LD50 (Oral)   (Rat as surrogate)   1,790   mg/Kg

LC50 (Inhal)   (Rat as surrogate)   7,300   ppm/hr

ENVIRONMENTAL FATE DATA
Abiotic:
Air (1/2 Life)   estimate based on OH radical reaction is 8 hours

Water (1/2 Life)   estimate for a model river/pond is 2.7/32 hours

Koc   model estimate based on Kow is 200

There is little information available on the environmental fate and
effects of this material. This compound is found in nature in manure
gas, crude oil, and plant volatiles. It has exhibited moderate
toxicity to the Rat in laboratory tests. It was highly toxic to the
Water flea in a single experiment. There is insufficient data to asses
biodegradability. If released to water or dry soil, it should rapidly
volatilize to the atomsphere. However, the estimated soil adsorption
coefficient indicates a moderate potential to sorb to organic carbon.
This compound is considered slightly soluble in water. The estimated
BCF suggests that this material should not bioaccumulate in aquatic
organisms. Caution should be exercised to prevent the accidental
release of this material to the environment.

12. ECOLOGICAL INFORMATION (Continued)

513-53-1 2-Butanethiol

AQUATIC ECOTOX DATA
            No data available

TERRESTRIAL ECOTOX DATA
            No data available

ENVIRONMENTAL FATE DATA
            No data available

There is no information available on the environmental fate and
effects of this material. Due caution should be exercised to avoid
the accidental release of this material to aquatic or terrestrial
environments.

13. DISPOSAL CONSIDERATIONS

Ensure that all responsible federal, state, and local agencies receive
proper notification of spill and disposal methods.

Dispose of in accordance with federal, state and local regulations.

14. TRANSPORT INFORMATION

DOT PROPER SHIPPING NAME: Flammable Liquid, NOS
                           (t-Butyl Mercaptan, Propyl Mercaptans)

DOT HAZARD CLASS: 3

DOT IDENTIFICATION NO: UN1993

DOT PACKING GROUP: II

DOT HAZARDOUS SUBSTANCE: Not Applicable

DOT MARINE POLLUTANT(S): Propanethiols
                          Butyl Mercaptan

ADDITIONAL DESCRIPTION REQUIREMENT: Not Applicable

15. REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS:

OSHA Standard 29 CFR 1910.1200 requires that information be provided
to employees regarding the hazards of chemicals by means of a hazard
communication program including labeling, material safety data sheets,
training and access to written records. We request that you, and it
is your legal duty to, make all information in this Material Safety
Data Sheet available to your employees.

15. REGULATORY INFORMATION (Continued)

To aid our customers in complying with regulatory requirements, SARA Title III Hazard Categories for this product are indicated below. If the word "YES" appears next to any category, this product may be reportable by you under the requirements of 40.CFR.370. Please consult those regulations for details.

TSCA:

All components of this product that are required to be on the TSCA inventory are listed on the inventory.

SARA/TITLE III HAZARD CATEGORIES:

Immediate(Acute) Health: YES   Reactive Hazard   NO
Delayed(Chronic) Health: NO   Sudden Release of Pressure NO
Fire Hazard: YES

HMIS HAZARD RATINGS:

HEALTH HAZARD: 2   FIRE HAZARD: 3   REACTIVITY: 0

STATE REGULATIONS:

See Section 2. COMPOSITION/INFORMATION ON INGREDIENTS list legend for applicable state regulation.

INTERNATIONAL REGULATIONS:

Consult the regulations of the importing country.

CANADA:

WHMIS Hazard Class: B2

16. OTHER INFORMATION

For additional non-emergency health, safety or environmental information telephone (972) 404-2405 or write to:

    Occidental Chemical Corporation
    Product Stewardship Department
    5005 LBJ Freeway
    P.O. Box 809050
    Dallas, Texas 75380

16. OTHER INFORMATION (Continued)

MSDS LEGEND:

ACGIH - American Conference of Governmental Industrial Hygienists

CAS = Chemical Abstracts Service Registry Number

CEILING - Ceiling Limit (15 Minutes)

CEL = Corporate Exposure Limit

OSHA - Occupational Safety and Health Administration

PEL = Permissible Exposure Limit (OSHA)

STEL - Short Term Exposure Limit (15 Minutes)

TDG = Transportation of Dangerous Goods (Canada)

TLV = Threshold Limit Value (ACGIH)

TWA = Time Weighted Average (8 Hours)

WHMIS - Worker Hazardous Materials Information System (Canada)

* = See Section 3 Hazards Identification - Repeated Exposure(Chronic)
    Information

IMPORTANT: The information presented herein, while not guaranteed,
was prepared by competent technical personnel and is true and accurate
to the best of our knowledge. NO WARRANTY OF MERCHANTABILITY OR
FITNESS FOR PURPOSE, OR OF ANY OTHER KIND, EXPRESS OR IMPLIED, IS MADE
REGARDING PERFORMANCE, STABILITY OR OTHERWISE. This information is
not intended to be all-inclusive as to the manner and conditions of
use, handling and storage. Other factors may involve other or
additional safety or performance considerations. While our technical
personnel will be happy to respond to questions regarding safe
handling and use procedures, safe handling and use remains the
responsibility of the customer. No suggestions for use are intended
as, and nothing herein shall be construed as a recommendation to
infringe any existing patents or violate any federal, state or local
laws, rules, regulations or ordinances.

17. WARNING LABEL INFORMATION

SIGNAL WORD:

DANGER

HAZARD WARNINGS:

Flash Point: -16°F (-26.7°C)

FLAMMABLE LIQUID.

PRECAUTIONS:

Liquid, vapors or mist may be irritating to eyes, skin and respiratory
tract.

17. WARNING LABEL INFORMATION (Continued)

FIRST AID

EYES:

IMMEDIATELY flush eyes with a directed stream of water for at least 15 minutes, forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue. IF IRRITATION PERSISTS GET MEDICAL ATTENTION.

SKIN:

Wash thoroughly with soap and water. Wash clothing before reuse. IF IRRITATION OCCURS, GET MEDICAL ATTENTION.

INHALATION:

Remove to fresh air. If breathing is difficult, have trained person administer oxygen. If respiration stops, have a trained person administer artificial respiration. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:

DO NOT INDUCE VOMITING. This material is not soluble. DO NOT GIVE FLUIDS. If spontaneous vomiting is inevitable, PREVENT ASPIRATION by keeping the victims head below the knees. GET IMMEDIATE MEDICAL ATTENTION. A qualified physician can perform gastric lavage only when the airway (trachea) has been secured to prevent aspiration.

IN CASE OF SPILL OR LEAK:

Avoid discharges to sewers and streams.

Shut off all sources of potential sparking or open flame.

Absorb in dry, inert material (sand, clay, sawdust).

FIRE:

Evacuate all unnecessary personnel. Shut down motors, pumps, electrical service and eliminate all sources of ignition. Use water spray to keep fire exposed containers cool to avoid pressure buildup. Wear NIOSH/MSHA approved positive pressure self-contained breathing apparatus and full protective clothing.

HANDLING AND STORAGE:

Avoid breathing vapor, use with adequate ventilation. Wear NIOSH/MSHA approved respiratory protection if there is potential for exposure above the exposure limits.

Do not get in eyes, on skin or clothing.

Keep away from sources of ignition. The vapors can travel to an ignition source and flash back causing a flash fire.

Store in a cool, dry, ventilated area away from heat, sparks and flame.

DISPOSAL:

Dispose of in accordance with federal, state and local regulations.

17. WARNING LABEL INFORMATION (Continued)

Ensure that all responsible federal, state, and local agencies receive proper notification of spill and disposal methods.

INFORMATION REQUIRED BY FEDERAL, STATE OR LOCAL REGULATIONS:

This Product Contains:

CAS#	NAME
75-66-1	2-Propanethiol, 2-methyl-
75-33-2	2-Propanethiol
107-03-9	1-Propanethiol
513-53-1	2-Butanethiol

VOC (g/l. by wt.): Not Determined

Contains no photochemically reactive material in accordance with Rule 443 of the South Coast Air Quality Management District.

HMIS RATING: HEALTH   2   FLAMMABILITY   3   REACTIVITY   0

LABEL NUMBER: 1097M36045

For Industrial Use Only

Attachment J
L/CNG Fueling Line Diagram

Vent

LNG
Storage

LNG Fueling

CNG
Dispenser

Heat
Exchanger

L/CNG Pump

LNG Pump

Pressure
Building /
Stauration
Coil

CNG Storage

Boiler

Coolant Pump

Hot
Water
Tank

DFW@2E L/CNG
Fueling Line
Diagram

Vent

LNG Storage

LNG Fueling

Heat Exchanger

CNG Dispenser

L/CNG Pump

M

LNG Pump

CNG Storage

Pressure Building / Stauration Coil

Boiler

Coolant Pump

Hot Water Tank

DFW@2E L/CNG Fueling Line Diagram

Vent

LNG
Storage

LNG Fueling

Heat
Exchanger

CNG
Dispenser

L/CNG Pump

M

LNG Pump

Pressure
Building /
Stauration
Coil

CNG Storage

Boiler

Hot
Water
Tank

Coolant Pump

DFW@2E L/CNG
Fueling Line
Diagram

Attachment K
Odorization System Calculations

ODORIZATION SYSTEM CALCULATIONS SHEET

*e_ nc_r c_*

Injection Rate Calculations

Odorant Weight by Volume : (A) __6.73 lbs / GAL__

Flow of Gas Per Day : (B) __432,000 SCF/DAY__   __.9 lbs__   [B x C = D]

Desired Injection Per Million Cubic Feet : (C) __1000,000 · F__

Pounds of Odorant Per Day : (D) __.3888 lbs/DAY__   [D / A = E]

Gallons of Odorant Per Day : (E) __.05777 GAL/DAY__   [E x 3786 = F]

Calculated CC's of Odorant Per Day : (F) __218.7 cc__   [F / 1440 = G]

CC's of Odorant Per Minute : (G) __.15 CC/min__   [G / H = I]

CC's of Odorant Per Stroke of Pump : (H) __1 CC__

Pump Strokes Per Minute : (I) __.15 STROKES/MIN__   [I x 1440 = J]

Pump Strokes Per Day : (J) _____   [B / J = K]

Flow Computer Output Scale Factor Calculation

Corrected Volume Output Pulse Scale Factor : (K) _____

Sight Feed Indicator Based Measured Concentration Calculations

Drops per minute through Sight Feed Assembly (L) _____   [L x .1 = M]

Pints per Day (M) _____   [M x 472 = N]

Measured CC's of Odorant Per Day : (N) _____

Pump Efficiency Calculation

Measured CC's of Odorant Per Day : (N) _____

Calculated CC's of Odorant Per Day : (F) _____   [N / F x 100 = O]

Percentage Pump Efficiency : (O) _____

Formulas

B x C = D   D / A = E   E x 3786 = F

F / 1440 = G   G / H = I   I x 1440 = J

B / J = K   L x .1 = M   M x 472 = N

N / F x 100 = O

$$\frac{0.9 \; lbs}{MMSCF}$$

Base Reference Standards

472 CC's Per Pint
3786 CC's Per Gallon
Reynolds R-12 (Linc 85-16) = .2 CC's Per Stroke
Reynolds R-25 (Linc 85-11) = .8 CC's Per Stroke
Reynolds R-50 (Linc 85-12) = 3.3 CC's Per Stroke
Williams DSP-125 = .1 CC's Per Stroke
Williams DSP-250 = .8 CC's Per Stroke
Williams DSP-500 = 3.2 CC's Per Stroke

Notes :

1) Pump volumes are listed at full stroke, a single digit increase or decrease on the micrometer is equal to one stroke per minute respectively.

2) Reynolds series pumps are slightly effected by increases pipeline pressure. As the pipeline pressure increases, the pump output volume decreases.

3) Make note of the Percentage Pump Efficiency (F) at start up or at the service interval and use that number as a base for future system performance evaluations.

For example, an R-25 pump should operate at .8 CC's per stroke, however, under 900 psi of pipeline pressure the volume per stroke output will be slightly lower. At start up, use the Pump Efficiency Formula to determine you best volume output, at pressure. Compare this value to future readings to determine true pump efficiency.

4) If your system is equipped with a Positive Displacement Flowmeter, allow for a 5 to 10 percent deviance between the Sight Glass calculations and the Meter readings. The Meter readings will be the most accurate.

PHYSICAL AND CHEMICAL PROPERTIES (Continued)

Vapor Pressure: 6.4 psia @ 100°F

Vapor Density (Air=1): 3.0

Density: 6.73 lbs. gal. @ 60°F

Evaporation Rate: Not Determined

% Volatiles by Wt: 100

Boiling Point: 138° - 155°F

Freezing Point: <-50°F

Melting Point: Not Determined

Solubility in Water (% by wt.): Negligible

pH: Not Determined

Octanol/Water Partition Coefficient: Not Determined

Thermal Decomposition Temperature: Not Determined

Other: Corrosion-Copper strip (24 hr. immersion test)
       negligible

VOC (g/l. by wt.): Not Determined

---

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY:

      X STABLE   _____ UNSTABLE

REACTS WITH:

_____	AIR	X	OXIDIZERS	_____	METALS
_____	WATER	_____	ACIDS	_____	OTHER
X	HEAT	_____	ALKALIS	_____	NONE

HAZARDOUS POLYMERIZATION:

      _____ OCCURS   X WILL NOT OCCUR

COMMENTS:
None.

HAZARDOUS DECOMPOSITION PRODUCTS:
Hydrogen sulfide.

Products of combustion include sulfur dioxide.

Attachment L
Electrical Riser Diagram

ELECTRICAL ROOM ON
SECOND FLOOR OF
AA MAINTENANCE BUILDING

EXISTING
120V/1∅

EXISTING
460/3∅

EXISTING
ELECTRICAL
ENCLOSURE

SOLA
POWER
CONDITIONER

NEW
120V/1∅
PANEL

EXISTING
CONTROLLER
PANEL

EXISTING
MOTOR
STARTER
PANEL

1¼"c

DISPENSER

L1

L2

CARD READER

L5

315
312,000 BTUH
BOILER

1.5 HP
COOLANT
PUMP

J-BOX

L3

CAUTION
LIGHT

L4

EXISTING
I/S
J-BOX

EXISTING
CONTROL
PANEL

J-BOX

5 HP
LNG
PUMP
EXISTING

25 HP
LNG
PUMP

CNG CANOPY

BOILER ROOM

EXISTING LNG SKID

ELECTRICAL RISER DIAGRAM

Attachment M
Water Heater Sizing

Lochinvar

COPPER FIN® Water Heaters

The Ultimate Water Heater — Combining Both Fuel Efficiency and Design Flexibility!

"This highly efficient concept combines 82% combustion efficiency with a simple, trouble free design, resulting in unequalled water heater durability, lime scale free operation and fewer service calls" — And that translates to customer satisfaction!

Copper Fin® Tube

Solid copper material eliminates worry about rust and corrosion. Copper Fin® heat exchanger fins are extruded from the tubing itself insuring maximum heat transfer efficiency for the life of the water heater.

Stainless Steel Burners

Provide durability, efficiency and low NOX emissions. Burners are adaptable to natural and liquified petroleum (LP) gases.

Loch-Heat® Ceramic Tile

Provides "space age" insulating technology and durability by eliminating the need for less efficient, bulky combustion chamber materials (refractory). Loch-Heat™ tile will not crack or spall and provides the benefit of an overall water heater weight reduction of 25% over other refractory materials.

Built-in Draft Hood

Reduces the cost of installation and lowers the overall height of the Copper Fin®, permitting installation in virtually all applications where head-room restrictions exist.
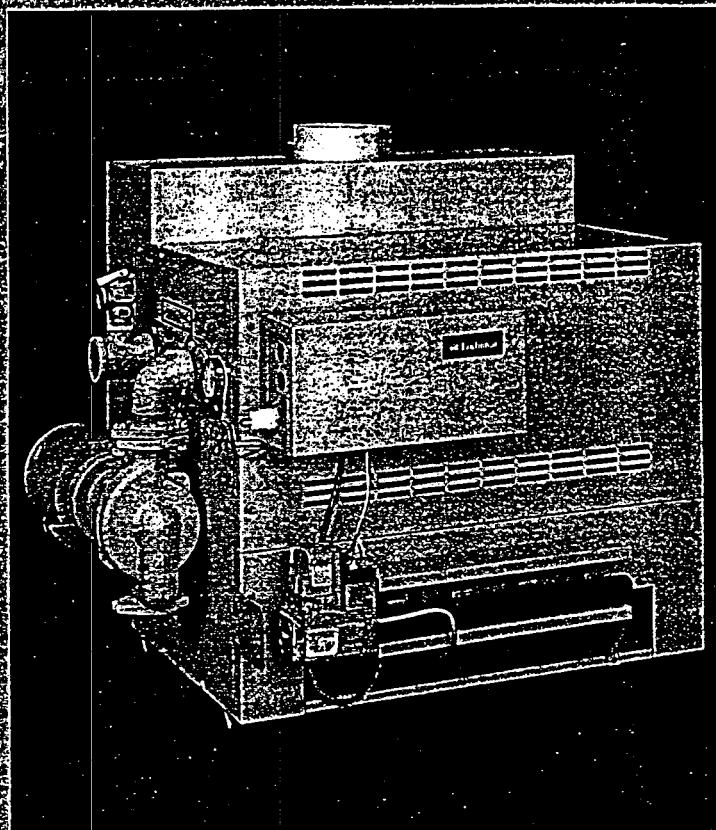
Available in several popular sizes designed to meet virtually any commercial application: 90,000, 135,000, 180,000, 199,000, 225,000, 270,000, 315,000, 360,000, 399,000, 500,000 B.T.U./Hr.

Serviceability

Copper Fin® provides quick and easy removal of all major components including burner tray, gas train and controls. The heat exchanger may be removed from the front of the water heater without disturbing the vent system or cabinet integrity. Copper Fin® — the most serviceable water heater on the market because servicemen and installers helped design it!

FULL 5 YEAR LIMITED WARRANTY

Standard Equipment

- High Limit Control
- Immersion thermostat — directly senses water temperature.
- Circulating Pump mounted.
- Individual inlet and outlet temperature gauges.
- 150 PSI ASME Temperature & Pressure Relief Valve.
- Galvanized Jacket.
- Built in draft hood.
- Gas valve with built in manual shut off.
- High-gloss acrylic paint.
- High Efficiency Stainless Steel Burners.
- Light weight *Loch-Heat*™ ceramic tile combustion chamber.
- ASME certified to 160 PSI working pressure.
- National Board Certified.
- AGA design certified for closet installation. (Models 090 through 180).
- AGA design certified for alcove installation. (Models 225 through 500).

Optional Features

- Flow Switch
- Vent Damper
- Combustible Floor Shield (except 399, 500)
- Manual Reset High Limit
- Low Water Cut Off (Probe Type)
- Pump Delay
- Spark Ignition (F-9) Models 090 through 270
- Modulating Gas Valve and Spark Ignition (M-9)

Dimensions and Specifications

Model #	BTU Input	GPH 100° Temp Rise	Gas Valve	V	Length	G	Wt.
RWN090PM-F1	90,000	89	1/2	5	18 1/2	5 3/4	157
RWN135PM-F1	135,000	134	1/2	5	22 1/2	5 3/4	178
RWN180PM-F1	180,000	179	3/4	6	26 1/2	5 3/4	194
RWN199PM-F1	199,000	198	3/4	6	29 1/2	11 3/4	211
RWN225PM-F1	225,000	224	3/4	7	29 1/2	11 3/4	211
RWN270PM-F1	270,000	268	3/4	7	32 1/2	11 3/4	226
RWN315PM-F9	315,000	313	1/2	8	35 1/2	11 3/4	240
RWN360PM-F9	360,000	358	1/2	8	38 1/2	11 3/4	258
RWN399PM-F9	399,000	397	1/2	10	47 1/16	11 3/4	280
RWN500PM-F9	500,000	497	1/2	10	53 3/4	11 3/4	290

Recovery based on actual heater performance at 82% (Change "N" to "L" to denote LP.)

Notes:
a. Pump pre-mounted /wired on all PM models.
b. Inlet and Outlet
   1½" N.P.T. 090 through 500.
c. Gas Valve inlet (L.P.)
   ½" — Models 090 through 180.
   ¾" — Models 225 through 500.
d. All models approved for Natural & L.P.

Firing Control Systems

F-1 Standing pilot, thermocouple supervision, standard equipment. (Models 090 through 270).

F-9 Electronic pilot supervision, spark ignition, 4 second main gas shutdown, standard equipment. (Models 315 through 500).

M-9 Same as F-9 with modulating gas valve.*
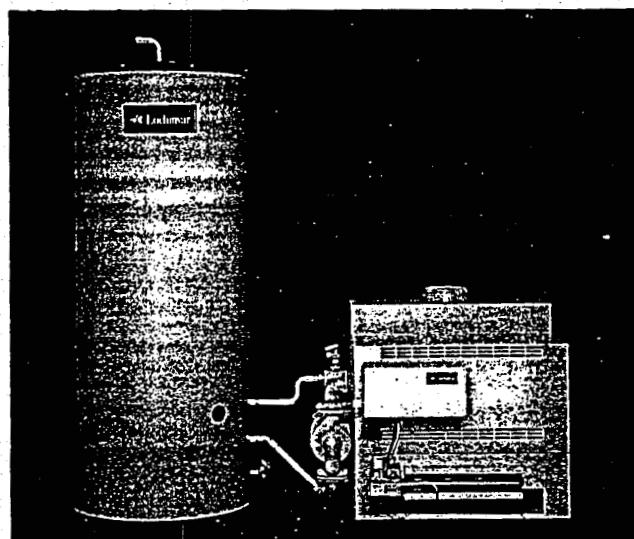
1½" flanged connections for ease of installation.

*Natural Gas only

gama

All models comply with ASME Boiler and Pressure Vessel Code Section IV, 160 P.S.I. Working pressure.

Water Heater Design certified by A.G.A. as automatic circulating water heaters for both Natural and L.P. Gas. Models 399 and 500 certified as Hot Water supply boiler under Z21.13.
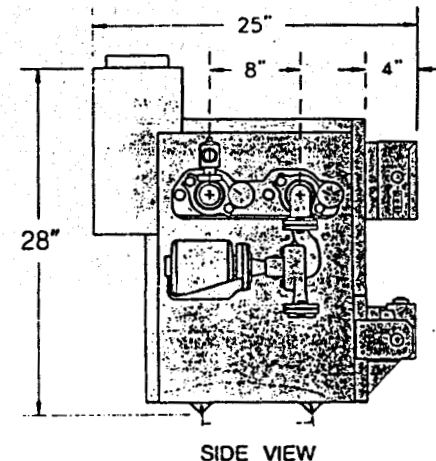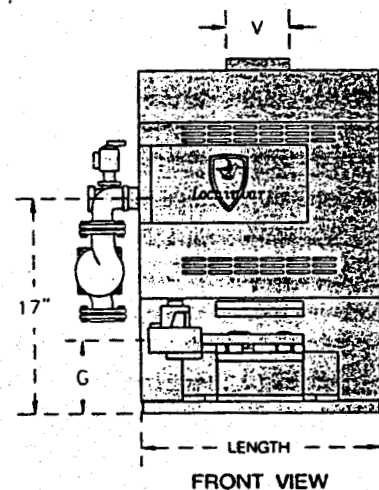
FRONT VIEW

SIDE VIEW

Lochinvar Water Heater Corporation
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Detroit, Michigan 48227 □ (313) 273-9500
FAX: 313-273-4328
Dallas, Texas 75234 □ (214) 484-8677
FAX: 214-247-1411

Lochinvar

BOILER COMPARISON

CB-HE-1

COPPER-FIN—THE MODERN, ENERGY EFFICIENT HOT WATER BOILER

The LOCHINVAR Copper-Fin Hot Water Boiler utilizes a heat exchange principle unlike conventional fire tube, water tube or cast iron sectional boilers. In the Copper-Fin Boiler, water is circulated through integrally-finned copper tubes which terminate in porcelainized cast-iron headers. This constant circulation of water provides several decided advantages not found in other type boilers:

A. *Controlled velocity scouring action* provided by the constant circulation of boiler water through the heat exchanger tubes. This prevents the build-up of lime, scale and sludge, maintains peak heat transfer efficiency.

B. *A higher "U" factor.* Coefficient of heat transfer is up to 10 times that of free (no velocity) convection.

C. *Higher thermal conductivity.* All-copper heat exchanger tubes have a thermal conductivity approximately 8½ times greater than cast iron boiler sections or steel tubes found in other types of boilers.

D. *Precise water temperature control* is achieved through continuous circulation through the heating system.

The integrally finned exterior (dry-side) of the copper heat exchanger tubes corresponds with other heat transfer sections of the heating system, such as finned baseboard radiation or wall convectors. Since water absorbs heat about 8 times faster than it can be extracted from the atmosphere of the combustion chamber, the exterior (dry side) heat exchanger fins are spaced 7 per inch and are designed to provide the proper amount of surface area to offset the difference in heat transfer rates between the dry and wet sides of the tubes.

All tubes of the Copper-Fin heat exchanger are on a horizontal plane to the combustion chamber, with each tube exposed to the same amount of heat. Contrast this with multi-tube and cast iron sectional boilers in which the upper layers of tubes or upper sections are furthest removed from the heat source, lowering the efficiency of these heat exchange surfaces.

Because the Copper-Fin Boiler contains a very low volume of water, response to demand for heat is practically instantaneous. For the same reason, at burner shut-down there is no wasteful temperature over-shoot.

The low water content of the Copper-Fin Boiler contributes substantially to the safety of the system because fewer BTU's (energy) are stored in the water than in other type boilers. Another safety consideration is utilization of an open, atmospheric type burner rather than a forced draft type combustion chamber, this design simplicity reduces maintenance costs and increases equipment life expectancy.

LOCHINVAR Copper-Fin Boilers are ideal as the heat source for dual temperature heating-cooling systems. The stress-free design permits the exchanger to "float" when subjected to the shock of rapid temperature changes. Because they are copper, the finned exchanger tubes are not subject to rusting-out from the condensation which may result from low operating temperatures.

The Copper-Fin Boiler requires only a fraction of the floor and head space required by conventional fire tube, water tube or cast iron sectional type boilers. Additionally, its light weight makes Copper-Fin ideal for penthouse or other weight sensitive areas.
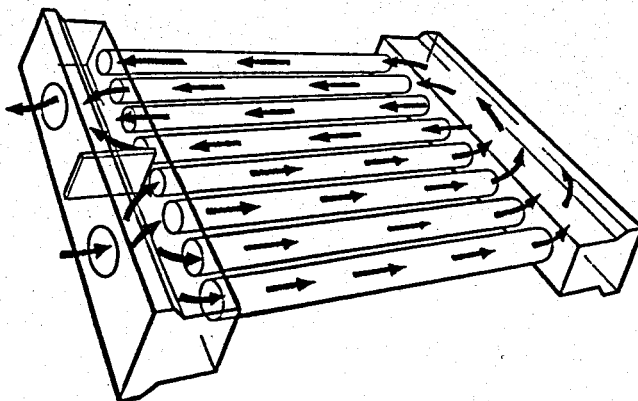
COPPER-FIN HEAT EXCHANGER
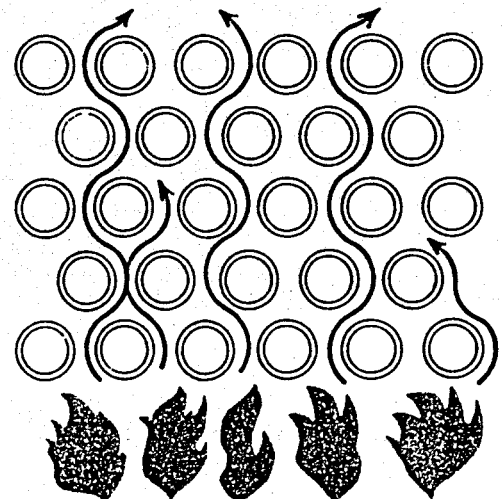
HORIZONTAL STEEL WATER TUBE CROSS SECTION

Lochinvar Water Heater Corporation
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FAX: 313-273-4328
Dallas, Texas 75234 □ (214) 484-8677
FAX: 214-247-1411

Low Water Temperature
Systems

WSHP-1

LOW WATER TEMPERATURE SYSTEMS

A number of hydronic boiler applications call for system water temperature operation in the range of 60° to 110° F. Several of the more typical of these applications are: Water Source Heat Pump Systems; Greenhouse Soil Heating and Irrigation Systems; Process or Manufacturing Operations.

Installations such as these, while increasingly common, often present problems resulting from boiler condensation, thermal stresses, and poor overall system efficiency. Copper Fin boilers are particularly adaptable to applications of this type for several reasons:

1. Copper-Fin is an instantaneous boiler, requiring virtually no heat-up time, and having no temperature "overshoot." Result? High system efficiency!
2. Copper-Fin's unique steel frame construction prevents the transfer of heat exchanger thermal stresses to other boiler components—reducing wear and tear, while increasing equipment life expectancy.
3. Copper-Fin's compact, simple design and low boiler mass permits condensation-free operation to temperatures as low as 60° F.

The piping illustration and instructions in Fig. 1 details a simple by-pass arrangement which will allow the system to be operated at any temperature above 60° F, without condensation forming in the boiler.

Condensation is prevented by simply regulating the flow balancing valve so as to divert sufficient water flow through the boiler to maintain water temperature at approximately 120° F, while allowing the system to operate at design temperature (as low as 60° F) See Fig. 1.

For Low Temperature Operation Proceed As Follows:

1. Select proper size boiler (without modulation).
2. Set boiler control thermostat at desired system temperature.
3. Start system and adjust balancing valve until boiler temperature rise stabilizes at approx. 50°-60° F differential. (Minimum Outlet Temp. 120° F)
4. Operate boiler until desired system operating temperature is achieved. Check out all components for proper operation.

Note: Closed Loop Systems may require an expansion tank, water feeder, air vents, and/or other components not furnished with the boiler.
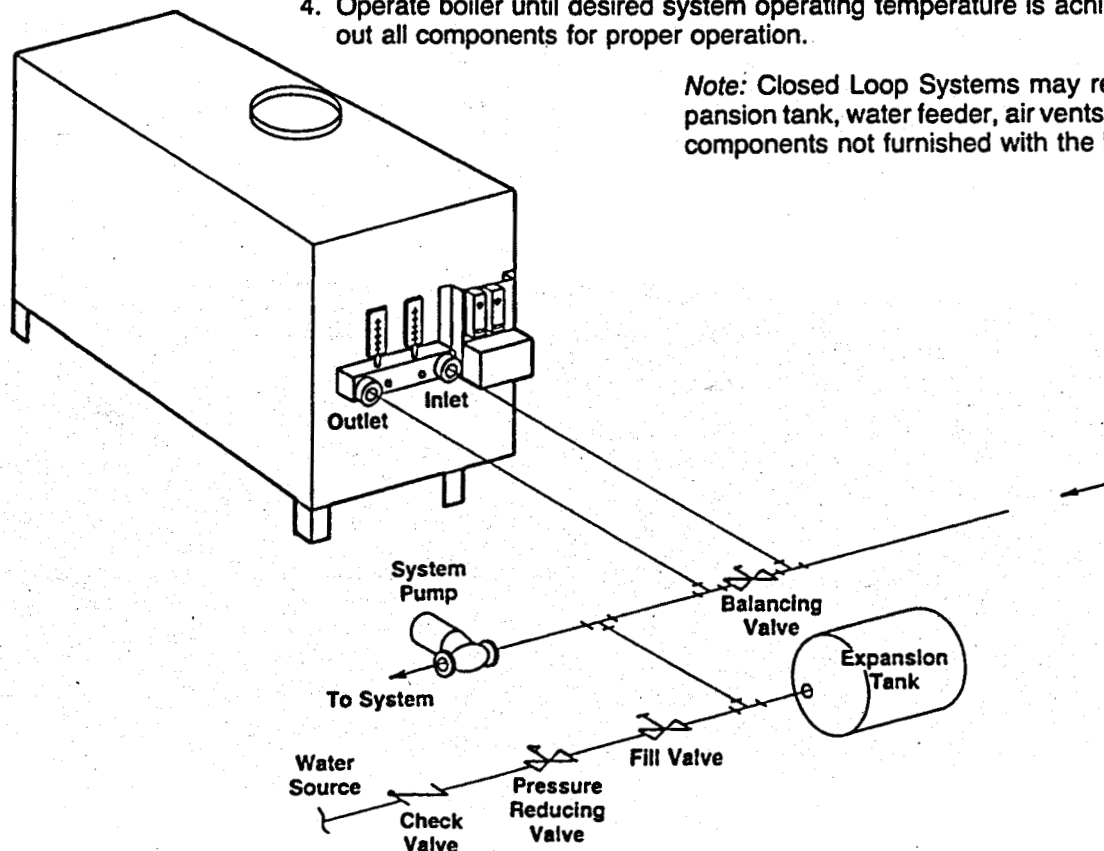
Fig. 1

Hydra Rig DESIGN CALCULATION

CUSTOMER/PROJECT: LONESTAR ENERGY

TITLE: WATER HEATER SIZING

BY: T. Preston

DATE: 4-30-96

PAGE: OF

JOB NO.: 31383

① INITIAL STORAGE SATURATION PRESSURE : 65 PSIA

② NOMINAL FLOW RATE OF CH_4 = 6 GPM

③ FINAL GAS TEMP : 40°F

④ LOWEST PUMPING PRESSURE : 3200 PSIG

Ⓐ INITIAL ENTROPY OF LNG : 1.328

Ⓑ ASSUME CONSTANT ENTROPY DURING ADIABATIC COMPRESSION OF LNG : ENTHALPY = -66.65 BTU/LB (H_I) AT 3200 PSIG.

Ⓒ FINAL ENTHALPY AT VAPORIZER DISCHARGE IS 151.8 BTU/LB (H_F) @ 40°F.

Ⓓ TOTAL ENTHALPY REQ'D = $H_T = H_F - H_I$

$$H_T = 151.8 \ BTU/LB - -66.65 \ BTU/LB$$

$$H_T = 218.45 \ BTU/LB$$

Ⓔ HEAT RATE REQ'D FOR VAPORIZATION

$$Q_R = \frac{218.45 \ BTU}{1 \ LB} \times \frac{3.243 \ LB}{1 \ GAL} \times \frac{6 \ GAL}{1 \ MIN} \times \frac{60 \ MIN}{1 \ HR} = 255,036 \ \frac{BTU}{HR}$$

Ⓕ PIPING IS 95% EFFICIENT SO $Q_A = \frac{255,036 \ BTU}{.95 \ HR}$

$$Q_P = 268,459 \ BTU/HR$$

Ⓖ HEATER IS 88% EFFICIENT SO $Q_H = \frac{268,459 \ BTU}{.88 \ HR}$

$$Q_H = 305,067 \ BTU/HR$$

Ⓗ NEXT SIZE UP FOR HEATER IS 315,000 BTU/HR MODEL. LOCKINVAR MODEL RW315

Ⓘ NOTE: RUNNING AT LOWER PRESSURES REQUIRES MORE HEAT DUE TO HIGHER FINAL ENTHALPY & LOWER LIQUID ENTHALPY. INITIAL PUMPUP OF CASCADE TO 3200 PSI WILL CAUSE LOW-TEMP SHUTDOWNS

Fluid = Methane

Pressure [psi]	Temp [F]	Density [lb/ft3]	Vsound [ft/s]	Entropy [Btu/lb-F]	Enthalpy [Btu/lb]	Compress [1/psi]
65.00	-219.6	24.26	3619.	1.328	-90.07	0.2720E-04

Fluid = Methane

Pressure [psi]	Temp [F]	Density [lb/ft3]	Vsound [ft/s]	Entropy [Btu/lb-F]	Enthalpy [Btu/lb]	Compress [1/psi]
4015.	40.00	14.10	2155.	1.886	144.3	0.1393E-03

Fluid = Methane

Pressure [psi]	Temp [F]	Density [lb/ft3]	Vsound [ft/s]	Entropy [Btu/lb-F]	Enthalpy [Btu/lb]	Compress [1/psi]
3215.	-208.0	25.32	4273.	1.320	-68.68	0.1686E-04
3215.	-207.9	25.32	4271.	1.320	-68.60	0.1687E-04
3215.	-207.8	25.31	4270.	1.321	-68.52	0.1689E-04
3215.	-207.7	25.31	4268.	1.321	-68.44	0.1691E-04
3215.	-207.6	25.31	4267.	1.321	-68.35	0.1692E-04
3215.	-207.5	25.30	4266.	1.322	-68.27	0.1694E-04
3215.	-207.4	25.30	4264.	1.322	-68.19	0.1696E-04
3215.	-207.3	25.29	4263.	1.322	-68.11	0.1697E-04
3215.	-207.2	25.29	4261.	1.323	-68.03	0.1699E-04
3215.	-207.1	25.28	4260.	1.323	-67.95	0.1701E-04
3215.	-207.0	25.28	4259.	1.323	-67.87	0.1702E-04
3215.	-206.9	25.27	4257.	1.324	-67.79	0.1704E-04
3215.	-206.8	25.27	4256.	1.324	-67.71	0.1705E-04
3215.	-206.7	25.27	4254.	1.324	-67.63	0.1707E-04
3215.	-206.6	25.26	4253.	1.324	-67.55	0.1709E-04
3215.	-206.5	25.26	4252.	1.325	-67.46	0.1710E-04
3215.	-206.4	25.25	4250.	1.325	-67.38	0.1712E-04
3215.	-206.3	25.25	4249.	1.325	-67.30	0.1714E-04
3215.	-206.2	25.24	4247.	1.326	-67.22	0.1716E-04
3215.	-206.1	25.24	4246.	1.326	-67.14	0.1717E-04
3215.	-206.0	25.23	4245.	1.326	-67.06	0.1719E-04
3215.	-205.9	25.23	4243.	1.327	-66.98	0.1721E-04
3215.	-205.8	25.23	4242.	1.327	-66.90	0.1722E-04
3215.	-205.7	25.22	4241.	1.327	-66.82	0.1724E-04
3215.	-205.6	25.22	4239.	1.328	-66.74	0.1726E-04
3215.	-205.5	25.21	4238.	1.328	-66.65	0.1727E-04
3215.	-205.4	25.21	4236.	1.328	-66.57	0.1729E-04
3215.	-205.3	25.20	4235.	1.329	-66.49	0.1731E-04
3215.	-205.2	25.20	4234.	1.329	-66.41	0.1732E-04
3215.	-205.1	25.20	4232.	1.329	-66.33	0.1734E-04
3215.	-205.0	25.19	4231.	1.330	-66.25	0.1736E-04

Fluid = Methane

Pressure [psi]	Temp [F]	Density [lb/ft3]	Vsound [ft/s]	Entropy [Btu/lb-F]	Enthalpy [Btu/lb]	Compress [1/psi]
3215.	10.00	13.73	1961.	1.867	124.2	0.1879E-03
3215.	11.00	13.67	1957.	1.869	125.1	0.1892E-03
3215.	12.00	13.62	1953.	1.871	126.1	0.1906E-03
3215.	13.00	13.57	1949.	1.873	127.0	0.1919E-03
3215.	14.00	13.52	1945.	1.875	127.9	0.1932E-03
3215.	15.00	13.46	1941.	1.877	128.9	0.1945E-03
3215.	16.00	13.41	1937.	1.879	129.8	0.1958E-03
3215.	17.00	13.36	1934.	1.881	130.7	0.1971E-03
3215.	18.00	13.31	1930.	1.883	131.7	0.1984E-03
3215.	19.00	13.26	1927.	1.884	132.6	0.1997E-03
3215.	20.00	13.21	1923.	1.886	133.5	0.2009E-03
3215.	21.00	13.16	1920.	1.888	134.4	0.2022E-03
3215.	22.00	13.11	1916.	1.890	135.4	0.2034E-03
3215.	23.00	13.06	1913.	1.892	136.3	0.2047E-03
3215.	24.00	13.01	1910.	1.894	137.2	0.2059E-03
3215.	25.00	12.96	1907.	1.896	138.1	0.2071E-03
3215.	26.00	12.91	1904.	1.898	139.0	0.2083E-03
3215.	27.00	12.86	1901.	1.900	140.0	0.2095E-03
3215.	28.00	12.81	1898.	1.902	140.9	0.2107E-03
3215.	29.00	12.76	1895.	1.904	141.8	0.2119E-03
3215.	30.00	12.72	1892.	1.905	142.7	0.2131E-03
3215.	31.00	12.67	1889.	1.907	143.6	0.2142E-03
3215.	32.00	12.62	1886.	1.909	144.5	0.2153E-03
3215.	33.00	12.57	1884.	1.911	145.5	0.2165E-03
3215.	34.00	12.53	1881.	1.913	146.4	0.2176E-03
3215.	35.00	12.48	1879.	1.915	147.3	0.2187E-03
3215.	36.00	12.43	1876.	1.917	148.2	0.2198E-03
3215.	37.00	12.39	1874.	1.918	149.1	0.2209E-03
3215.	38.00	12.34	1871.	1.920	150.0	0.2220E-03
3215.	39.00	12.29	1869.	1.922	150.9	0.2230E-03
3215.	40.00	12.25	1867.	1.924	151.8	0.2241E-03
3215.	41.00	12.20	1864.	1.926	152.7	0.2251E-03
3215.	42.00	12.16	1862.	1.927	153.6	0.2261E-03
3215.	43.00	12.11	1860.	1.929	154.5	0.2271E-03
3215.	44.00	12.07	1858.	1.931	155.4	0.2281E-03
3215.	45.00	12.02	1856.	1.933	156.3	0.2291E-03
3215.	46.00	11.98	1854.	1.935	157.2	0.2301E-03
3215.	47.00	11.94	1852.	1.936	158.1	0.2311E-03
3215.	48.00	11.89	1850.	1.938	159.0	0.2320E-03
3215.	49.00	11.85	1848.	1.940	159.9	0.2329E-03
3215.	50.00	11.81	1846.	1.942	160.8	0.2339E-03
3215.	51.00	11.76	1845.	1.943	161.7	0.2348E-03
3215.	52.00	11.72	1843.	1.945	162.6	0.2357E-03
3215.	53.00	11.68	1841.	1.947	163.5	0.2366E-03
3215.	54.00	11.64	1840.	1.949	164.3	0.2374E-03
3215.	55.00	11.59	1838.	1.950	165.2	0.2383E-03
3215.	56.00	11.55	1836.	1.952	166.1	0.2392E-03
3215.	57.00	11.51	1835.	1.954	167.0	0.2400E-03
3215.	58.00	11.47	1833.	1.955	167.9	0.2408E-03
3215.	59.00	11.43	1832.	1.957	168.8	0.2416E-03
3215.	60.00	11.39	1831.	1.959	169.6	0.2424E-03
3215.	61.00	11.35	1829.	1.960	170.5	0.2432E-03
3215.	62.00	11.31	1828.	1.962	171.4	0.2440E-03
3215.	63.00	11.27	1827.	1.964	172.3	0.2448E-03
3215.	64.00	11.23	1825.	1.966	173.2	0.2455E-03

3215.	65.00	11.19	1824.	1.967	174.0	0.2463E-03
3215.	66.00	11.15	1823.	1.969	174.9	0.2470E-03
3215.	67.00	11.11	1822.	1.971	175.8	0.2478E-03
3215.	68.00	11.07	1821.	1.972	176.6	0.2485E-03
3215.	69.00	11.03	1820.	1.974	177.5	0.2492E-03
3215.	70.00	11.00	1819.	1.975	178.4	0.2499E-03

Fluid = Methane

$$24.26 \frac{\#}{FT^3} \times \frac{FT^3}{1728\,IN^3} \times \frac{231\,IN^3}{GAL} = 3.243\ \#/GAL$$

Pressure [psi]	Temp [F]	Density [lb/ft3]	Vsound [ft/s]	Entropy [Btu/lb-F]	Enthalpy [Btu/lb]	Compress [1/psi]
40.00	-234.0	25.08	3909.	1.275	-102.8	0.2159E-04
41.00	-233.3	25.05	3896.	1.277	-102.2	0.2182E-04
42.00	-232.6	25.01	3882.	1.280	-101.6	0.2205E-04
43.00	-232.0	24.97	3869.	1.282	-101.0	0.2227E-04
44.00	-231.3	24.93	3856.	1.285	-100.5	0.2250E-04
45.00	-230.7	24.90	3843.	1.287	-99.90	0.2272E-04
46.00	-230.1	24.86	3830.	1.290	-99.35	0.2295E-04
47.00	-229.4	24.83	3818.	1.292	-98.80	0.2317E-04
48.00	-228.8	24.79	3806.	1.294	-98.26	0.2340E-04
49.00	-228.2	24.76	3794.	1.297	-97.73	0.2362E-04
50.00	-227.6	24.72	3782.	1.299	-97.21	0.2384E-04
51.00	-227.0	24.69	3770.	1.301	-96.69	0.2407E-04
52.00	-226.5	24.66	3758.	1.303	-96.18	0.2429E-04
53.00	-225.9	24.62	3747.	1.305	-95.68	0.2452E-04
54.00	-225.3	24.59	3735.	1.307	-95.18	0.2474E-04
55.00	-224.8	24.56	3724.	1.309	-94.69	0.2496E-04
56.00	-224.2	24.53	3713.	1.311	-94.20	0.2519E-04
57.00	-223.7	24.50	3702.	1.313	-93.72	0.2541E-04
58.00	-223.2	24.47	3691.	1.315	-93.25	0.2563E-04
59.00	-222.6	24.43	3681.	1.317	-92.78	0.2586E-04
60.00	-222.1	24.40	3670.	1.319	-92.32	0.2608E-04
61.00	-221.6	24.37	3660.	1.321	-91.86	0.2630E-04
62.00	-221.1	24.34	3649.	1.323	-91.40	0.2653E-04
63.00	-220.6	24.31	3639.	1.325	-90.96	0.2675E-04
64.00	-220.1	24.29	3629.	1.327	-90.51	0.2698E-04
65.00	-219.6	24.26	3619.	1.328	-90.07	0.2720E-04
66.00	-219.1	24.23	3609.	1.330	-89.64	0.2743E-04
67.00	-218.6	24.20	3599.	1.332	-89.21	0.2765E-04
68.00	-218.2	24.17	3589.	1.334	-88.78	0.2788E-04
69.00	-217.7	24.14	3580.	1.335	-88.36	0.2811E-04
70.00	-217.2	24.11	3570.	1.337	-87.94	0.2833E-04
71.00	-216.8	24.09	3561.	1.339	-87.53	0.2856E-04
72.00	-216.3	24.06	3551.	1.340	-87.12	0.2879E-04
73.00	-215.9	24.03	3542.	1.342	-86.71	0.2901E-04
74.00	-215.4	24.01	3533.	1.344	-86.31	0.2924E-04
75.00	-215.0	23.98	3524.	1.345	-85.91	0.2947E-04
76.00	-214.6	23.95	3515.	1.347	-85.51	0.2970E-04
77.00	-214.1	23.93	3506.	1.348	-85.12	0.2993E-04
78.00	-213.7	23.90	3497.	1.350	-84.73	0.3016E-04
79.00	-213.3	23.87	3488.	1.352	-84.34	0.3039E-04
80.00	-212.9	23.85	3480.	1.353	-83.96	0.3062E-04
81.00	-212.4	23.82	3471.	1.355	-83.58	0.3085E-04
82.00	-212.0	23.80	3462.	1.356	-83.20	0.3108E-04
83.00	-211.6	23.77	3454.	1.358	-82.83	0.3132E-04
84.00	-211.2	23.75	3445.	1.359	-82.46	0.3155E-04
85.00	-210.8	23.72	3437.	1.360	-82.09	0.3178E-04
86.00	-210.4	23.70	3429.	1.362	-81.73	0.3202E-04
87.00	-210.0	23.67	3421.	1.363	-81.36	0.3225E-04
88.00	-209.6	23.65	3412.	1.365	-81.00	0.3249E-04

Attachment N
Tescom Regulator

DOME LOADED — PRESSURE REDUCING REGULATOR

26-1100 SERIES

LOADING DOME
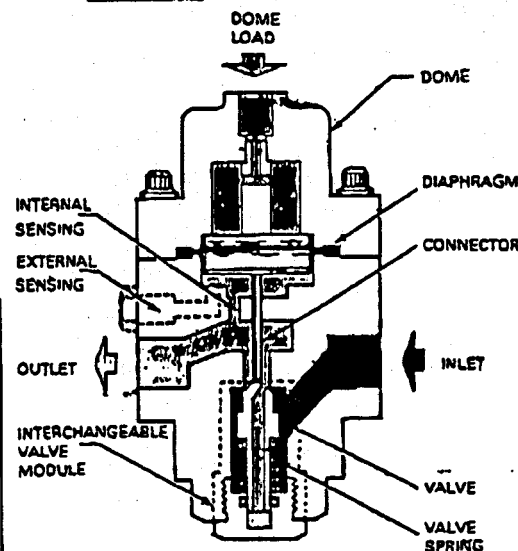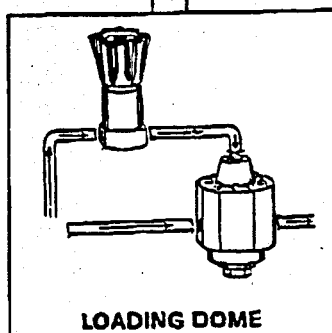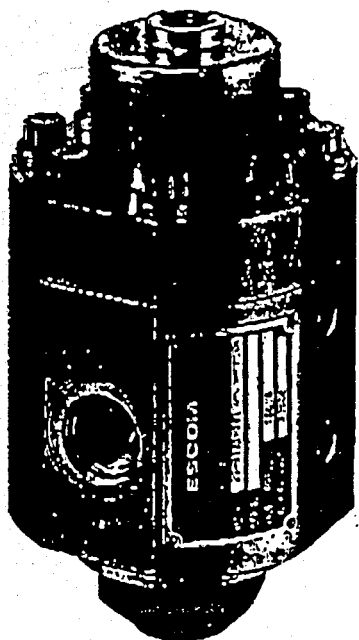
FUNCTIONAL SCHEMATIC

HIGH FLOW • SMALL-COMPACT • HIGH PRESSURE CAPABILITY

The 26-1100 series is a direct acting, diaphragm sensing, externally gas loaded, dome pressure reducing regulator. Designed for accurate control of primary pressures while providing high flow rates. This model features the balanced main valve principle which permits:

• Uniform outlet pressures with variable inlet pressures.
• Smaller sensing area which results in a smaller envelope design.
• Reduced seat load which insures longer seat life.
• Wide flow range capability.

The 26-1100 series is available in brass, aluminum, stainless steel, and will accurately regulate inlet pressures up to 6000 PSIG (415 bar) and 10,000 PSIG (700 bar) in stainless steel.

• Balanced stem
• Diaphragm sensitivity
• External sensing available
• Low droop, low lock-up
• Rapid response time
• Used with liquids or gases
• Numerous porting options
• Mountable in any position
• Modular construction
• Two orifice sizes available ¼ and ⅜ diameter

TYPICAL APPLICATIONS

Master or Station Regulator
Component Testing
High Flow Purge Systems
Research Laboratories
Manifold Regulator
Industrial Applications
Pneumatic or Hydraulic Test Consoles

TESCOM
C O R P O R A T I O N

INDUSTRIAL CONTROLS DIVISION
12616 Industrial Boulevard
Elk River, Minnesota 55330-2491

(612) 241-3238 FAX (612) 241-3224

INSTALLATION DIMENSIONS
METRIC EQUIVALENTS IN PARENTHESES (MILLIMETERS)

26-1100 SERIES

PANEL CUT-OUT DIMENSIONS-REF.

ALL DIMENSIONS ARE REFERENCE ONLY

SPECIFICATIONS

FLUID MEDIA – All gases and liquids compatible with materials of construction.
Maximum rated inlet pressure (Stainless Steel) .... 10,000 PSIG **
(700 bar)
Maximum rated Inlet pressure (Aluminum, Brass) .... 6,000 PSIG
(415 bar)
Outlet pressure range .... 55 PSIG (3.79 bar) to maximum Inlet
Design proof pressure .... 150% maximum operating
Design burst pressure .... 400% maximum operating
Materials .... Body — Stainless, Aluminum or Brass
Dome —Stainless, Aluminum or Brass
Diaphragm – Buna-N
Seat – Kel-F®
Seals – Buna - N
Gaskets – Kel-F®
Trim – 300 Series Stainless
Flow Capacity .... (.25 Orifice) Cv = .46
Flow Capacity .... (.375 Orifice) Cv = 1.30
Ambient operating and fluid media temperature ..... - 65° to +165°F
(-54° to +75° C)
Leakage .... Bubble tight
Weight – Stainless .... 10 lbs. (4.5 kg.)
 – Aluminum .... 4 lbs. (1.8 kg.)
Ports .... See Ordering Information

ORDERING INFORMATION

26 - 1121 - 381

TINA

389-1275
$130 PS E K P #
387-1419

| BASIC SERIES NUMBER |

| BODY AND DOME MATERIAL |
1—Brass
2—303 SST
3—Aluminum

| LOADING METHOD |
1—External

| ORIFICE SIZE** |
1—.250 Dia. Orifice
2—.375 Dia. Orifice

| PORT SIZE |
6-3/8"
8-1/2"

INLET AND OUTLET PORT TYPE	DOME PORT TYPE
1—SAE	3—MS33649-4
2—NPT	2—NPT 1/4"
3—MS33649	3—MS33649-4

**Note: .375 Orifice size has maximum rated inlet of 6,000 PSIG (415 bar)

STANDARD MODIFICATIONS
(See Price List)

Add suffix "001" to part number to specify external sensing capability.

Add suffix "044" to part number to specify standard model but with all 316 Stainless Steel construction.

Add suffix "061" to part number to specify standard model but with 9/16" AMINCO inlet and outlet ports.

Add suffix "074" to part number to specify brass construction. with internal load and bleed valves and Viton-A soft goods.

Kel-F® is a registered trademark of 3M
Viton-A® and Teflon® are registered trademarks of DuPont

OXYGEN SERVICE:
Specification of materials in regulators used for oxygen service is the USER'S RESPONSIBILITY. Cleaning for oxygen service to 3000 PSIG can be supplied by Tescom at no additional cost. Cleaning for service above 3000 PSIG may be performed to the user's specifications through an outside source.

ACCESSORIES   (Optional at Extra Cost)
Soft goods kits (standard models):
.250 Dia. Orifice Size . . . . .P/N 389-1163
.375 Dia. Orifice Size . . . . .P/N 389-1164

Standard repair kits (soft and metallic):
.250 Dia. Orifice Size . . . . P/N 38-1111-26
.375 Dia. Orifice Size . . . . P/N 38-1121-26
Kit for field conversion to external sensing . . . . .P/N 389-1022
CONSULT FACTORY FOR KITS ON MODIFICATIONS.

FLOW CHARTS

REGULATOR DISCHARGE CHARACTERISTICS CURVES

REGULATOR DISCHARGE CHARACTERISTICS CURVES
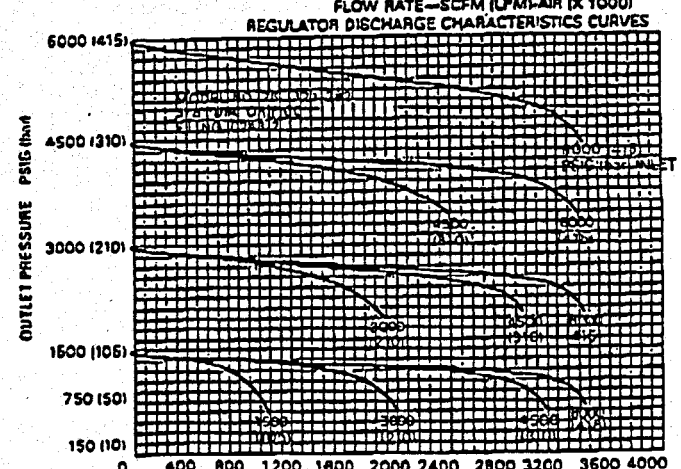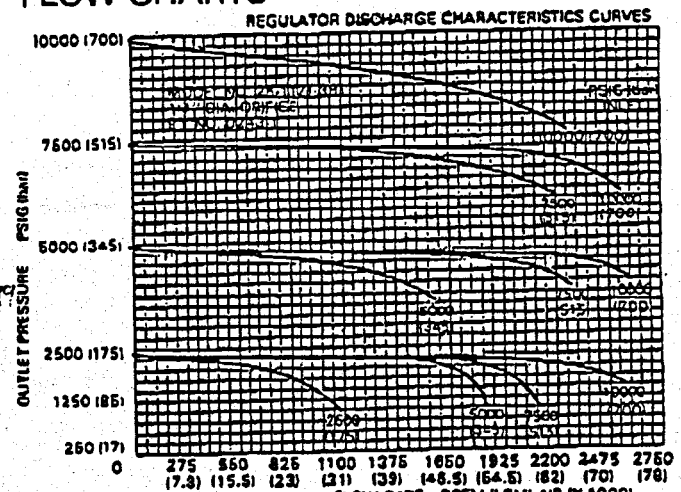
NOTE: ALL UNITS IN PARENTHESES ARE IN METRIC AND OPEN TYPE FIGURES ARE ENGLISH UNITS.

HAND LOADED PRESSURE REDUCING REGULATOR 44-1100 SERIES

IN-LINE

CONTROL KNOB
LOAD SPRING
VENT VALVE
SENSOR
CONNECTOR
MAIN VALVE
OUTLET
INLET
FILTER

FUNCTIONAL SCHEMATIC
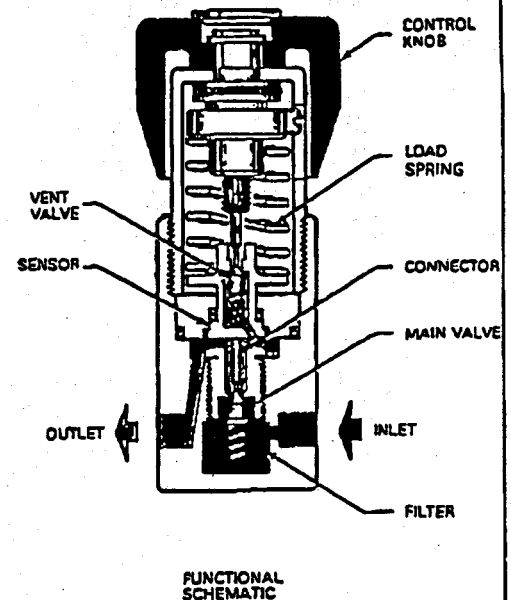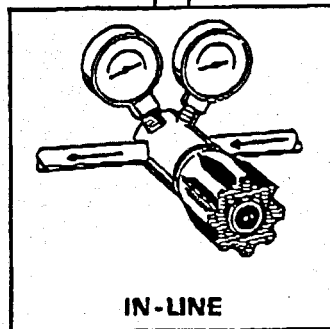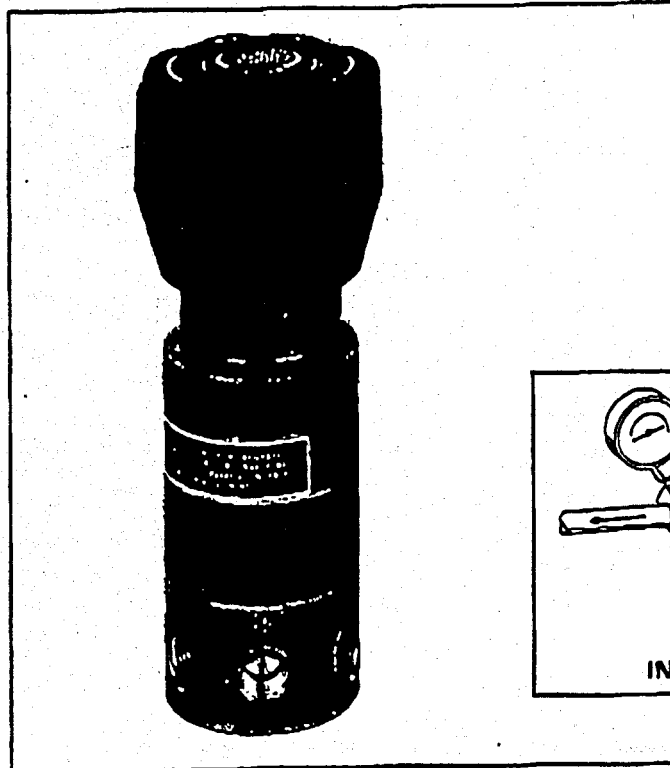
HIGH PRESSURE CAPABILITY • EXCELLENT SENSITIVITY • SELF-VENTING

The 44-1100 series high pressure regulators are designed to safely reduce inlet pressures of up to 10,000 PSIG (700 bar) and accurately provide six secondary outlet pressure ranges. The pressure ranges are obtainable with one regulator by installing one of a combination of three load springs and three sensors. These are available in kit form and can be installed while the regulator is in the system. This self-venting regulator allows operator to reduce pressure setting in a closed system by venting the downstream pressure through the regulator. A non-venting version is also available.

- Removable valve assembly module permits ease of repair
- Available in brass or stainless steel construction
- Excellent sensitivity through a wide range of pressure settings
- Extra safety and reliability of spring loaded piston sensor

- Unbalanced stem assures positive shut-off
- Large handknob provides fast low-torque pressure settings
- Available with or without gauges and CGA connection

TYPICAL APPLICATIONS

Calibration Kits
Airline Charging Carts
Chemical Plants
Manufacturing Processes
Research and Development Laboratories

TESCOM
C O R P O R A T I O N

INSTALLATION DIMENSIONS   **44-1100 SERIES**

(METRIC EQUIVALENTS IN PARENTHESES IN MILLIMETERS)

ALL DIMENSIONS ARE REFERENCE ONLY.
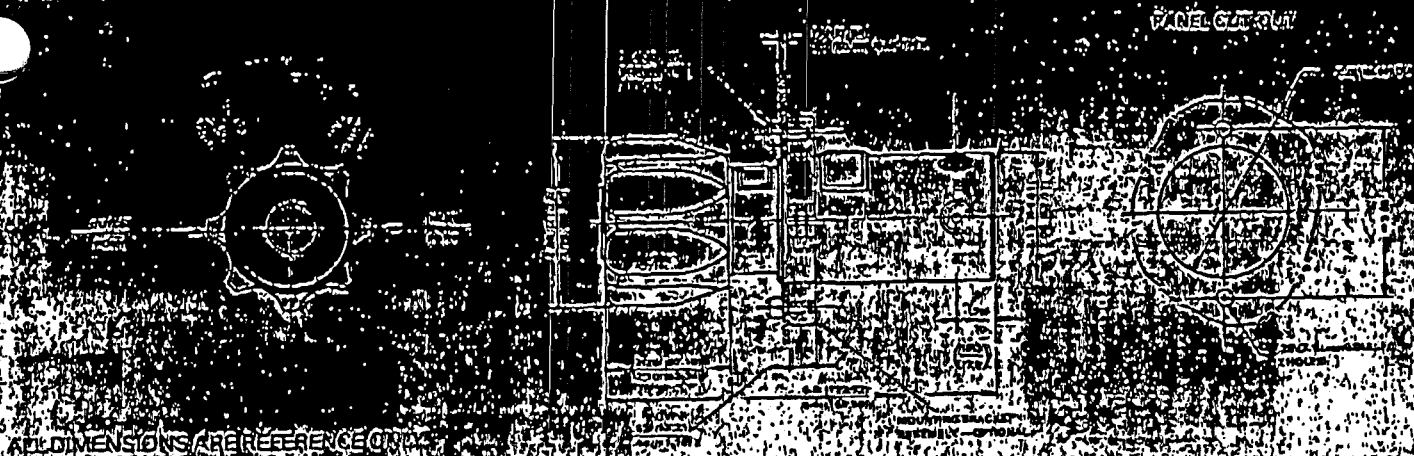
SPECIFICATIONS

FLUID MEDIA – All gases compatible with materials of construction. For other media, consult factory.
Maximum rated inlet pressure (Stainless) . . 10.000 PSIG (700 bar)
Maximum rated inlet pressure (Brass) . . . . . 6,000 PSIG (415 bar)
Outlet pressure ranges* 0-500. 0-800, 10-1500, 15-2500,
                                                  25-4000, 50-6000 PSIG
             (0-35, 0-55, .69-105, 1.03-175, 1.72-280, and 3.45-415 bar).
Proof pressure . . . . 150% Maximum operating
Burst pressure . . . . 400% Maximum operating
Materials . . . . Body – Brass or 303 Stainless Steel
                                   Bonnet – Brass or Plated Brass
       Brass Models: 20 Micron (Nom.) Filter – Bronze
       Main Valve Seat – Vespel®/Vent Valve Seat – Kel-F®
                                                    Seals – Buna-N
                                   Back-up Rings – Teflon®
                                   Trim – 300 Series Stainless
Flow Capacity . . . . C_v = .06
Ambient operating and fluid media temperature –40°F to + 165°F
                                                 (–40°C to + 75°C)
Leakage . . . . Bubble tight
Weight (w/o gauges) . . . . 4¾ lbs. (2.15 kg.)
Ports . . . . ¼" NPT inlet, outlet and gauge ports
Maximum operating torque . . . . 40 lb.-in. (46 kg-cm)

*NOTE: Regulators vent to zero PSIG (zero bar) in all pressure ranges.

ORDERING INFORMATION

44-1111-24

| BASIC SERIES NUMBER |

| **BODY MATERIAL** |
| 1 – Brass |
| 2 – 303 Stainless Steel |

| **OUTLET PRESSURE RANGE** |
| 1 – 0-500 PSIG (0-35) |
| 2 – 0-800 PSIG (0-55) |
| 3 – 10-1500 PSIG (.69-105) |
| 4 – 15-2500 PSIG (1.03-175) |
| 5 – 25-4000 PSIG (1.72-280) |
| 6 – 50-6000 PSIG (3.45-415) |

| **PORT SIZE** |
| 4 – 1/4" |

| **PORT TYPE** |
| 2 – NPT |

STANDARD MODIFICATIONS

Add suffix "001" to part number for Viton-A® O-Rings and Non-Venting.
Add suffix "002" to part number for non-venting modification of the standard model with filter removed.
Add suffix "009" to part number for Viton-A® O-Rings and Teflon® Back-up Rings.

OXYGEN SERVICE
Specifications of materials in regulators used for oxygen service is the USER'S RESPONSIBILITY. Cleaning for oxygen service to 3000 PSIG can be supplied by Tescom at additional cost. Cleaning for service above 3000 PSIG may be performed to the user's specifications through an outside source.

ACCESSORIES (Optional at Extra Cost)

GAUGES: Consult Accessories Section

CYLINDER CONNECTIONS – Order by CGA connection number. The most popular are CGA 350 (Hydrogen), CGA 540 (Oxygen), CGA 580 (Nitrogen) and CGA 590 (Air).

Soft goods kit (standard models) . . . . P/N 389-1275
Standard repair kit (soft and metallic) . . . . P/N 389-1449
Multiple range kit (see catalog page) . . . . P/N 38-144X-XXX-XX
Panel mounting bracket assembly . . . . P/N 1129
Main valve service tool . . . . P/N 6557-3
CONSULT FACTORY FOR KITS ON MODIFICATIONS.

DFW LONG

FLOW CHART

REGULATOR DISCHARGE CHARACTERISTICS CURVES

FLOW RATE—S C F M · (LPM) AIR

Printed in U.S.A.
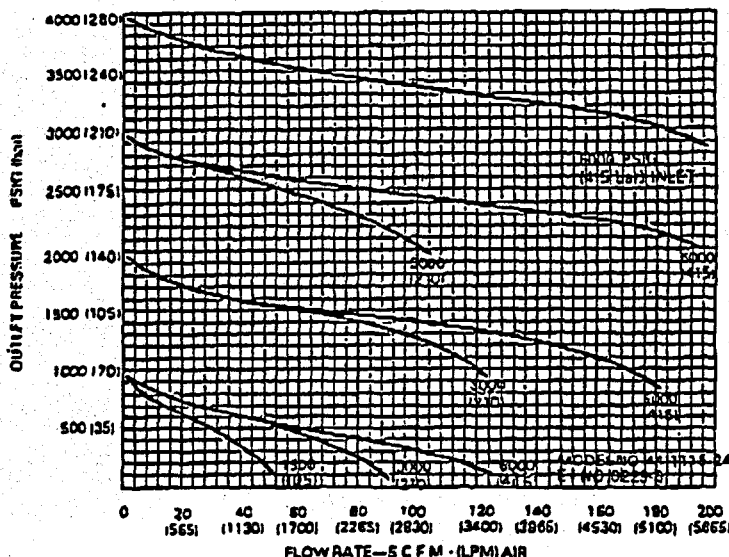
Attachment O
Station Design Description

Drexel

STANDARD EQUIPMENT SPECIFICATION
Skid Mounted Liquid Natural Gas Station
Ambient Conditioning System

DATE: OCTOBER 24, 1994   STANSPEC NO. 519

1.0 SCOPE OF WORK

1.1 The scope of this specification is to define a temporary LNG Fueling Station which can be moved to any desired location on a standard drop deck trailer with a 48" tall (max.) x 36 ft. long lower deck.

2.0 CONSTRUCTION

2.1 All components of the station will be mounted on a steel skid 8 ft. wide x 36 ft. long x 9.5 ft. high. The major components would be:

    2.1.1 5,000 gallon horizontal cryogenic tank
    2.1.2 30 GPM cryogenic pump
    2.1.3 LNG dispensing and metering system
    2.1.4 Fluid conditioning and control module

2.2 The controller is mounted on a separate detachable skid, which is to be remotely located 100' from the main skid and connected with an umbilical and piping.

3.0 COMPONENT DESCRIPTION

3.1 5,000 gallon cryogenic storage vessel

    3.1.1 Double wall vacuum insulated cryogenic vessel.
    3.1.2 Net volume - 5,000 gallons with 5% ullage
    3.1.3 Liquid level indicator
    3.1.4 Standard fill and vent connections
    3.1.5 Relief valves
    3.1.6 90% trycock
    3.1.7 Pump suction connection
            Pump return connection
            Gas return connection

3.2 30 GPM Cryogenic Pump

    3.2.1 Capable of 30 GPM @ 60 PSI differential pressure
    3.2.2 Secondary pressure transfer

3.3 LNG Dispenser

    3.3.1 Valving to permit recirculation of liquid back to storage tank or direct it to the vehicle.
    3.3.2 Mass flow meters to measure liquid into the vehicle and vapor out of the vehicle with indication of net fuel delivered to the vehicle.
    3.3.3 Back pressure valve to maintain vehicle tank pressure.
    3.3.4 Control panel to control the complete station.

3.3.5 There will be two (2) cryogenic hoses 12 ft. long to transfer fuel to the vehicle. These hoses will be insulated. The nozzle connection to the vehicle will be supplied by the customer.

3.3.6 Control system will be capable of automatically conditioning the storage tank to optimum pressure conditions to assure adequate NPSH for the transfer pump.

3.3.7 The system shall be capable of fueling a vehicle at 60 PSI with a flow rate of 30 GPM.

3.3.8 The vent return hose from the vehicle shall be equipped with a liquid sensor to sense a full vehicle tank and to prevent circulation of liquid thru the vent system of the dispenser.

3.4 Conditioning

3.4.1 Capable of conditioning fuel to any desired saturation level.

3.5 Skid

3.5.1 The skid is constructed of steel and designed such that it can be loaded and unloaded over the rolling tailboard of an oilfield trailer or lifted directly using a four point sling.

Length............................36 ft.
Width..........................   8 ft.
Height.:.......................9.5 ft.
Weight (empty)............36,000# Approx.

3.6 Piping

3.6.1 The piping shall be of sufficient size to affect an efficient transfer of cryogenic fuel from the storage tank to the vehicle. The active piping shall be vacuum jacketed.

3.7 Codes

3.7.1 NFPA 59A

3.7.2 ASME Section VIII, Division 1

3.7.3 ASME B31.3

3.8 Controller Skid

3.8.1 This skid will contain the controller and motor switching gear. It must be remotely located from the main skid by 100 ft. Its connection will be umbilical cords.

3.8.2 External service required to this component is:

	Pump	Controller
Voltage	460	120
Phase	3	1
Frequency	60HZ	60
Power	5KW	30 Amps

4.0   GENERAL

4.1   All components on the main skid shall be explosion proof to Class I, Division 1, Group D.

4.2   All components shall be cleaned, primed, and painted with Epoxy paint.

4.3   Unit shall be completely tested with LN_2 prior to shipment.

Attachment P
Controller and Software

OPTO 22

DATA SHEET

Form 588-980128

Part Number	Description
G4LC32SX	Classic SX Controller

Description

The G4LC32SX is a cost effective, high performance controller designed to work within the Opto 22 family of rugged, compact controllers and I/O units. A 32-bit 68020 microprocessor supports up to four serial ports, a selectable ARCNET port, and a high speed local port for flexible communication.

Programming is accomplished with OptoControl or Cyrano Opto 22's revolutionary flow chart based programming languages. Programs are transportable across the entire line of Opto 22 processors.

G4LC32SX
CONTROLLER

B3000

B3000

B3000

REMOTE BUS RS-485

SNAP-B8M
SNAP 8 MODULE RACK
WITH SNAP BRAIN

SNAP-B12MC
SNAP 12 MODULE RACK
WITH SNAP BRAIN

SNAP-B16M
SNAP 16 MODULE RACK
WITH SNAP BRAIN

Description (CONT.)

SOFTWARE

The G4LC32SX is designed to work in combination with FactoryFloor, Opto 22's new suite of Windows 32-bit software, which delivers total control to industrial automation customers. FactoryFloor consists of three integrated components:

- OptoControl, a graphical, flowchart-based development environment for control solutions
- OptoDisplay, a graphical, multimendia operator interface package
- OptoServer, a robust data server that connects the controller network with the PC-based FactoryFloor network.

G4LC32SX configuration and development are performed through OptoControl on a PC workstation. OptoControl is an easy to use, self-documenting control environment that uses a plain English command set and a long tagname database that is shared by all FactoryFloor components. The G4LC32SX also works with Opto 22's classic 16-bit software: Cyrano, Mistic MMI and Mistic Data Server (MDS.)

COMMUNICATION OPTIONS (STANDARD)

The G4LC32SX base unit has the following communication ports:

- 2 full-duplex combined RS-232 or RS-422/485 serial ports, 300-115kBd
- 1 Mistic local bus port, 1.44 MB/s

INTERFACE OPTIONS (ADAPTER CARDS)

Two interface cards are available to increase your communication options.

Interface Adapter Cards	Function
G4LC32SER	2 RS-232/RS-485 high speed serial ports
G4LC32ARC	ARCNET and 2 RS-485 ports

Opto 22 • 43044 Business Park Drive • Temecula, CA 92590 • Phone: (909) 695-3000 • (800) 321-OPTO • Fax (909) 695-3095 • Internet: www.opto22.com

Inside Sales: (800) 452-OPTO • Product Support: (800) TEK-OPTO • (909) 695-3080 • Fax: (909) 695-3017 • E-mail: support@opto22.com • FaxBack: (800) 474-OPTO

OPTO 22

CONTROLLERS
CLASSIC

DATA SHEET

page 3/5

Form 588-980128

Description (CONT.)

I/O CONNECTIVITY

The RS-422/485 ports can be used as a serial link to communicate with remote digital and analog I/O units. Up to 4096 I/O points can be connected to each communication port. Additional serial ports can be obtained with the G4LC32SER or G4LC32ARC.

MEMORY EXPANSION OPTIONS

The RAM can be used to store a user's control strategy (program) and data. The flash memory (ROM) stores a kernel (operating system) and can be used to store a control strategy permanently. The use of flash technology allows the user to remotely download new firmware offered by Opto 22.

RAM: Base, 256K
     Expansion: 1 M. Buy 2 G4RAM4M

ROM: Base, 256K
     Expansion: 1 M. Buy G4LC32F1M

POWER SUPPLIES

Three power supplies are available. They supply enough power to operate the G4LC32SX base unit and seven I/O units (bricks.)

Power Supply Model Number	Voltage
G4PS245A	120 VAC
G4PS245AFM	120 VAC Factory Mutual Approved
G4PS245B	220 VAC

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DATA SHEET

Form 588-980128

Specifications

CPU	32-bit Motorola 68020 processor IEEE floating-point math
CPU clock frequency	16.67 MHz

Memory
  RAM
  Flash EEPROM on controller
	256 KB - 1 MB with battery backup (user programs & data)
	256 KB - 1 MB (firmware and user programs)

RAM/clock battery	3.6-volt lithium, non-rechargeable
I/O	Via RS-485 ports, using Opto 22 I/O
Communication	2 combined RS-232 or RS-485/422 port Via daughter cards: configurable serial ports, ARCNET, Local bus port
Real-time clock	Clock/calendar, Epson 62421A with battery back
Power requirements	5 VDC ± 0.1 @ 2.0 A
Typical operating temperature	0° C to 70° C
Storage temperature	0° C to 70° C
Humidity	5% to 95% relative humidity
Software	FactoryFloor (OptoControl, OptoDisplay and Optoserver) Classic Software (Cyrano, Mistic MMI, MDS)

System monitors
  Host communications
 	
  RAM battery backup low
  Operating temperature
	Detect communication errors from processor, I/O, etc.
	Detect main power supply operation
	Detects program corruption (check sum RAM test)
	Detects temperature

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CONTROLLERS
CLASSIC

page 5/5

Dimensions

5.50" (139.7mm)

4.35" (110.5mm)

10.50"
(266.7mm)
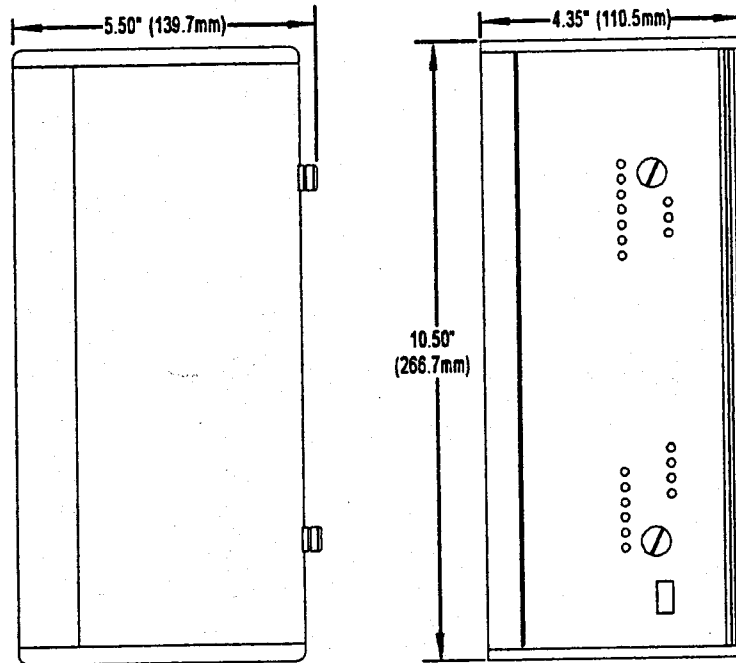
OPTO 22

SOFTWARE
FACTORYFLOOR

Form 848-970226

Part Number	Description
FACTORYFLOOR	FactoryFloor Suite
OPTOCONTROL	OptoControl
OPTODISPLAY	OptoDisplay
OPTOSERVER	OptoServer

FactoryFloor® takes you a quantum leap ahead in your search for total control of the manufacturing enterprise. To solve the toughest control automation problems, or build the easiest to use, most informative user interfaces, or to expand your manufacturing systems connectivity, Opto 22 has a total control solution called FactoryFloor, Opto 22's new suite of Windows® 32-bit applications, which is designed to deliver total control to industrial automation customers. FactoryFloor consists of three integrated components:

- OptoControl™ a graphical, flowchart-based development environment for control solutions
- OptoDisplay™ a graphical multimedia operator interface package
- OptoServer™ a robust data server that connects the controller network with the PC-based FactoryFloor network

Opto 22's leadership and innovation in industrial automation hardware and software, combined with Microsoft®'s operating environments and applications, provides a solid foundation for total control. Opto 22's combination of hardware and software expertise, and its belief in the importance of open systems integration, sets them sharply apart from firms that can only deliver pieces of the puzzle.

FactoryFloor takes advantage of the power of Microsoft Windows® 95, Microsoft Windows NT™ and Microsoft Office software products to deliver a complete client/server solution for industrial automation. This reduces training requirements and increases productivity. The power of the Windows programming standards means ease of integration with other applications.

FactoryFloor offers a total control solution from programming and debugging a control system to a networked human/machine interface, all from the same vendor who delivers world-class control auto-mation hardware.

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Opto 22's history of innovation in control hardware and flowchart-based software, combined with Microsoft Windows 95 and Windows NT, provides a foundation for the world's most powerful graphical development environment for control solutions - OptoControl. OptoControl is the cornerstone of Opto 22's FactoryFloor suite of Windows 32-bit applications and is designed to deliver maximum flexibility and control to the industrial automation customer.

OPTOCONTROL GRAPHICAL CONFIGURATOR

Flowcharts are developed by using 4 simple constructs:
- Action blocks contain a list of things to do;
- Condition blocks contain one or more things to test for;
- Connections indicated the sequence of execution;
- Continue blocks allow you to jump to other areas in the chart.

A control program consists of any number of flowcharts. OptoControl's real-time multi-tasking lets you run up to 30 charts simultaneously.

Powerful subroutine builder allows OptoControl to be easily expanded.

The "Strategy Tree" allows you to point and click to display or edit the configuration of any item in the control strategy.
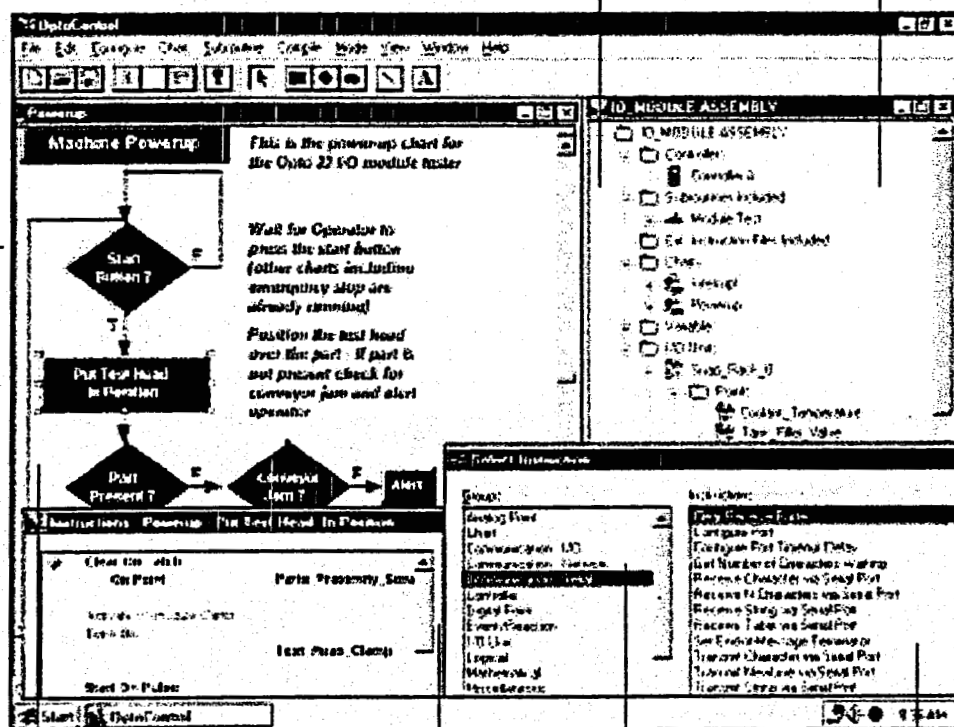
OptoControl programs are easy to maintain because the flowcharts are self-documenting.

Plain English commands are used to control I/O, perform communications and do math functions. All variables and I/O points are given meaningful names. Standard data types include: Floating point, integer, ASCII strings, and tables of all three types.

Powerful network communications include Ethernet with TCP/IP.

Extensive ASCII string handling and serial communications capabilities offer unprecedented control of serial devices.

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DATA SHEET

Form 848-970226

OptoControl takes advantage of the graphical Windows 95 interface to make it easy to understand, configure, design and troubleshoot your solution in a distributed client-server environment. Some key features that make OptoControl easy to use are:

- OptoControl's Strategy Tree provides a graphical tree-like view of your control system configuration.
- OptoControl's flowchart programming environment provides a precise, graphical view of your control process.
- OptoControl's animated debugger makes it easy to step through your process and see what's happening at every point in your control program.
- OptoControl's subroutine builder provides extensive code reusability by packaging flow charts for later use.

All these tools can be live and function on your workstation at the same time, thanks to Windows' multitasking.

One of the fundamental advantages of OptoControl is its ease of use. Since it is virtually self-documenting, existing programs can be easily understood which simplifies and streamlines the maintenance process. Every time the program or system configuration is changed, the documentation will reflect the latest changes. This usability is further enhanced by the use of a plain English command set, and a long-tag-name database.

The OptoControl long-tag-name database is shared by all FactoryFloor applications and is open and accessible to third-party applications using the built-in software developers kit (SDK). Eliminating duplicate databases makes the programmer's job easier and reduces the margin for error. OptoControl also uses the communications enabling technologies inherent in Windows to provide open access to the control system database for third party and custom development.

FLOWCHARTING

Because complex processes are easier to understand using graphics and symbols, OptoControl uses a powerful, flowchart-based language which lets programmers write programs visually, making the design phase much less abstract. OptoControl also improves communication between design team members already familiar with flowcharts by providing a consistent programming environment for control program logic and instructions.

PROGRAMMING

OptoControl is designed to make it easy to program your control process, unlike conventional methods that simply evolved from the old electromechanical wiring layouts for relays. OptoControl is easier to learn, easier to use and is designed to harness all the power of Opto 22's distributed control hardware platform.

Configurator

OptoControl's configurator provides an intuitive user interface that graphically documents the control strategy. The flowcharts are created using a very simple set of drawing tools. Instruction insertion and editing is accomplished through the use of standard pull-downs, dialogs, and controls that are now a familiar part of all Windows-based software packages.

Using simple objects, programmers lay out the logic of the program by creating a flowchart. Action blocks contain a list of things to do, condition blocks contain one or more things to test for, connections show the sequence of operations and continue blocks allow jumps to other areas in the chart. By choosing from menus and assigning long descriptive names to I/O points and variables, programmers can add the appropriate details to each block. Once I/O points and variables are named and defined, they go into the OptoControl database and never have to be referenced by characteristics again, only by name.

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OptoControl Animated Debugger
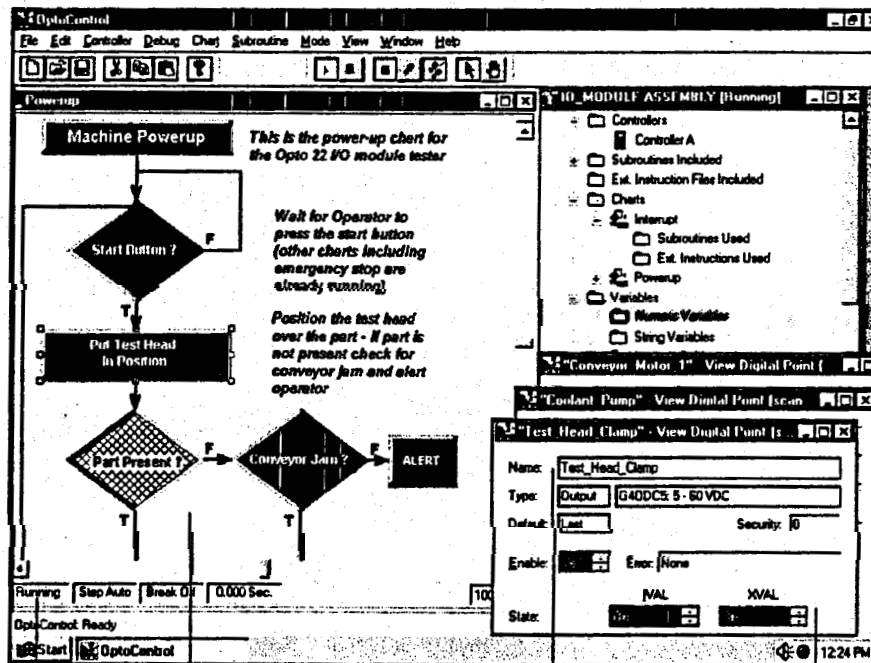
Status bar includes monitors for chart state, step mode, and breakpoints as well as a timer indicating elapsed execution time.

Animated debugger supports autostep, single-step, and breakpoints for testing, verifying and trouble shooting.

OptoControl's open tagname database is utilized by all Opto 22 FactoryFloor applications and is easily accessible to third party software packages.

Any control object (variables, I/O points, etc.) can be viewed and manipulated in real-time.

Command Set and Subroutines

OptoControl provides programmers with an extensive command set which handles a variety of data types, including integer, floating point, ASCII string, and arrays of each. Sophisticated ASCII string handling also provides unprecedented control over serial ports. The OptoControl Subroutine Configurator lets the programmer create and archive subroutines which can then be called up and executed by multiple programs, as specified by the programmer. Once a subroutine is created it becomes an integral part of the OptoControl command set.

STRATEGY TREE

The entire system configuration is graphically presented in the Strategy Tree. The Strategy Tree is a hierarchical tree-like representation of the Opto 22 control system. Each object configured as part of the OptoControl strategy has an associated

icon. Controllers, I/O points, variables and even the logic itself are represented. Using the Strategy Tree, programmers simply point and click to display or edit system configuration items while at the same time looking at the flowchart and logic associated with the object.

DEBUGGER

OptoControl's animated, real-time debugger makes it easy to check out system configuration or follow the flow of control logic to understand what is happening. The debugger presents a tightly integrated user interface that allows the programmer to get an application up and running as fast as possible. The programmer may enter break points, do single step functions and manipulate I/O points and variables while the program is running. This mode of the OptoControl environment speeds checkout of the entire system. It is also a very powerful diagnostic and troubleshooting tool for maintenance personnel after the project is in production.

DATA SHEET

Form 848-970226

OptoDisplay is a 32-bit Windows-based graphical multimedia operator interface package designed to work as part of the "Total Control Solution" provided by Opto 22's FactoryFloor suite. In addition to OptoDisplay, FactoryFloor includes:

- OptoControl, a graphical flowchart based development environment
- OptoServer, a robust data server that connects the controller network with the PC-based FactoryFloor network.

OptoDisplay gives operators, technicians and engineers the information they need at a glance. OptoDisplay allows you to construct your operator interface by designing graphical objects. Displays can combine pictures, symbols, bitmaps and 3-D graphics from OptoDisplay's extensive library. Display functions can include controller-driven animation and operator-driven commands. Operators can also utilize real-time data for trend plotting. OptoDisplay is easy to program — just point, click and associate. The power of OptoDisplay lies in its tight integration with the OptoControl software and its ability to monitor and interact with Opto 22's world-class hardware. Advanced features enable you to animate any graphical control object and to associate it with real-world events by choosing a tag name from the shared OptoControl database. Use your mouse to select the items you want from the OptoControl strategy and associate them with your OptoDisplay graphic objects or historical collection files.

OPTODISPLAY GRAPHICAL MULTIMEDIA OPERATOR INTERFACE

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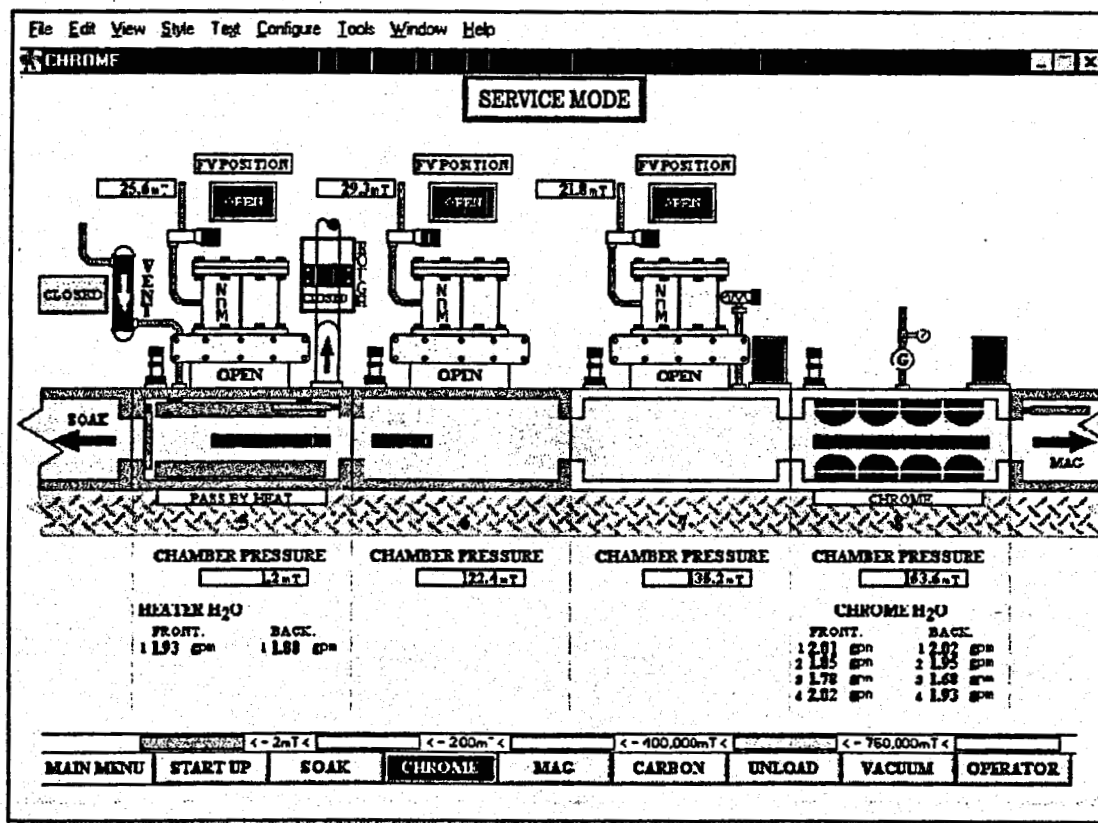
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DATA SHEET

Form 848-970226

OptoServer is the client-server application component of FactoryFloor that gathers and serves requested data among the clients on the FactoryFloor network.

The FactoryFloor network consists of the hardware controllers and the PC-based workstations that control them. Combined with Microsoft's communication enabling technologies, OptoServer becomes the universal I/O server.

OptoServer is fully integrated with OptoDisplay and OptoControl and is used in stand-alone applications or within a complex client/server architecture. OptoServer can also be integrated with Microsoft products, third-party packages, and/ or user-developed custom applications created with tools such

as Microsoft Visual Basic[e].

OptoServer is another example of how FactoryFloor uses Microsoft Windows-based standards to provide world-class support to Opto 22 customers. FactoryFloor encourages open systems solution development by customers, integrators and third-party developers. For example, you can use OptoServer to access FactoryFloor data from custom solutions built with Microsoft Access, Microsoft Visual Basic or Microsoft Excel. OptoServer is designed to help you reach out, not to fence you in.

Opto 22 designed OptoServer to be easy to manage with features like built-in diagnostics, report by exception and support for backup servers.

OPTOSERVER SYSTEM CONFIGURATION

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SET FLG LNG DIPENSING
SYSTEM ON

SET PUMP SPEED = 12

DRIVEAWAY PROTECTION?

SET FOR CH4 AT 100 PSI SAT LIQ

```
 0    START

26    SET INDEX=0

27    GET TEMP & PRESS

28    GET TABLE VALUES

29    <MPS_MATCH>   --F-->   31 INCREMENT INDEX

      T (from 29)

30    SAT. PRESSURE

32    INDEX=250?
        T --> (to 26)
        F --> (to 28)
```

```
                    ┌─────────────────┐
                    │ 0    START      │
                    └────────┬────────┘
                             │
                             ▼
                    ┌─────────────────┐
                    │ 28 ESS-SYSTEM C.D. │
                    └────────┬────────┘
                             │
                             ▼
                    ┌─────────────────┐
                    │ 29 OPEN VALVES  │◄──────────┐
                    └────────┬────────┘           │
                             ▼         F          │
                          ◇ 31 ◇ ──────────►  ▓▓▓▓▓▓▓▓
                       MER-SYS_CD                ▓▓▓▓▓▓▓▓
                             │ T
                             ▼
                    ┌─────────────────┐
                    │ 32 RIME LNG PUMP │
                    └────────┬────────┘
                             │
                             ▼
                    ┌─────────────────┐     TPLX ALARM CHART WILL
                    │ 30 ART TPLX SD CH│     RESTART TPLX SD CHART
                    └────────┬────────┘
                             │
                             ▼
                    ┌─────────────────┐                              ┌──────────────────┐
                    │ 5 MESS-SYSTEM STAR │◄─────────────────────────│ 26 LOSE PC VALVE │
                    └────────┬────────┘                              └──────────────────┘
                 F           ▼                                                 ▲ T
            ▓▓▓▓◄───── ◇ 9 START_ON? ◇                            ◇ 25 G_TPLX_CH ◇
            ▓▓▓▓             │ T              ┌──────────────────┐  F
                             ▼        ┌──────│ 27 PEN PC VALVE  │◄────
                 F     ◇ 14 START_OFF ◇       └──────────────────┘
            ▓▓▓▓◄─────       │
            ▓▓▓▓             │ T
                             │                ┌─────────────────┐    ┌────────────────────┐
                             │                │ 3 SHUTDOWN LNG  │    │ 23 SHUTDOWN LNG/CNG │
                             ▼                └─────────────────┘    └────────────────────┘
                    ┌─────────────────┐              ▲ T                       ▲
                    │ 13 START DISPENSER │───────►  ◇ 24 MP_MODE_O ◇  F ────────┘
                    └─────────────────┘              │ T
                                          ◇ 1 STOP_ON? ◇  F        CHECK FOR SATURATION
                                                                   CHART ON CONDITION
                                                                   ▓▓▓▓▓▓▓▓
```

TPLX ALARM CHART WILL RESTART TPLX SD CHART

CHECK FOR SATURATION CHART ON CONDITION

0 TART_FILL_TABL

1 PRESS VS TEMP

2 TEMP VS DENSITY

3 FILL MESSAGES

9 END

```
  0
    START_BLOCK
       │
       ▼
 51   STOP CHARTS
       │
       ▼
 45   SET VARIABLES
       │
       ▼
 35   SET OUTPUTS
       │
       ▼
      SET COM PORTS
       │
       ▼
 38 FILL MESS/TABLES
       │
       ▼
 41   BRIGHT SCREEN
       │
       ▼
 53 DELAY FOR DISPLY
       │
       ▼
 40   START CHARTS
       │
       ▼
 43      END
```
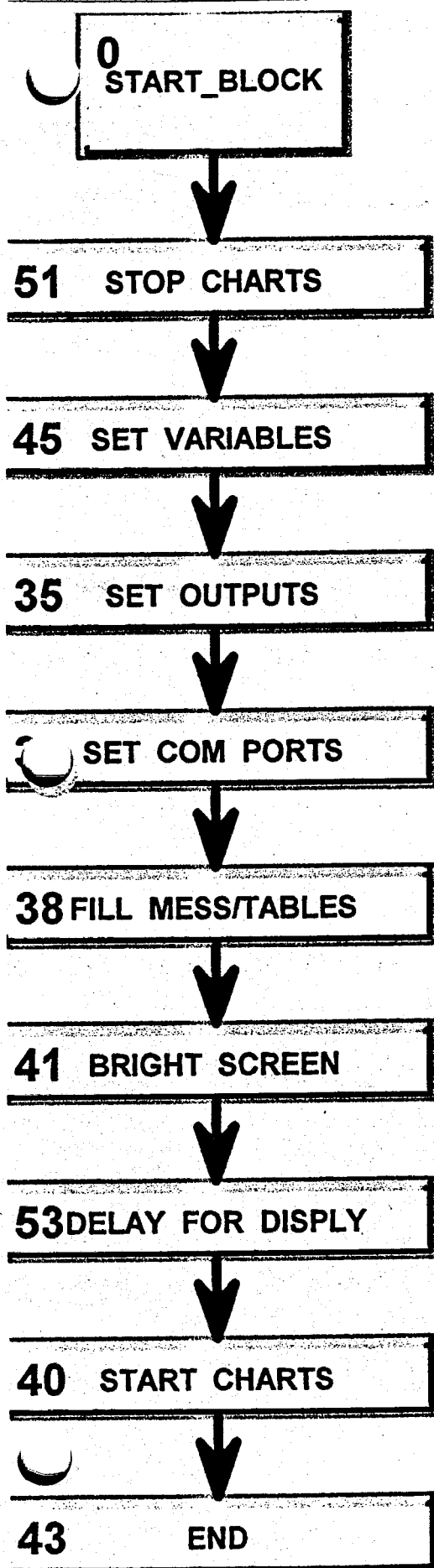
**ADD ALL CNG FLAGS
AND OUTPUTS**

**FOR HIGH PRESS STORAGE
ADD CHART TO CONVERT
0-5VDC PSI WHERE
0.5 V = 0 PSI
4.5 V = 7112 PSI**

START_BLOCK

SWITCHES OPEN(OFF) IN ALARM
EXCEPT LEAK DETECTION

7 =RG_STOP_AL=   F

35 =K_ALARM_O=   T

9 =ST_AIR_ALA=   F

24 =W_FUEL_ALA=   F

28 =K_PRESS_HI=   F

T

T

T

T

T

10 MESS-EMERG STOP
11 MESS-LEAK DETECT
12 MESS-LOST AIR
25 MESS-LOW FUEL
29 ESS-HIGH PRESS

13 TURN OFF CHARTS
48 TURN OFF CHARTS2
31 TURN CHARTS OFF

41 SET WATER PUMPS
40 =-TPLX_CHT_=   T   F
46 SET WATER PUMP2
47 =-TPLX_CHT_=   T   F
50 SET WATER PUMP3
51 =-TPLX_CHT_=   T   F

14 SHUTDOWN SYSTEM
45 SHUTDOWN SYSTEM2
49 SHUTDOWN SYSTEM3

15 =RMS_RESET   F
16 =ER+H2O_PUM=   T
42 COOL PUMP OFF

34 =R_STOP_ALA=   T
F
33 =PRESS_<=13U=   F
T

18 TURN OFF ALARMS

21 MESS-RESET SYS

23 RESET_ON?   F
44 =ER+H2O_PUM=   T
43 COOL PUMP OFF-

T

20 RESET_OFF?   F

22 POWERUP CHART ON

26 END

**CNG STORAGE PRESSURE
NOT INCLUDED**

START

1 UMP_FLOW_ — T — 10 OW INDEX CP= — 2 UMP_FLOW — T — 22 OW INDEX-HP= — 3 ALRM_TPLX_ — T — 4 ALRM_TPLX_ — T — 5 STR-PRESS_ — T — 6 STR-TEMP_On — T

F

7 JW_FLAG_ON — F

T

9 REM_FLW_IND

18 OW_INDEX=1

T

11 T_FLAG-CP_FLO

8 JW_FLAG_ON — F

T

20 REM_FLW_IND

21 JW_INDEX=1 — F

T

12 IT_FLAG-WP_FLC

13 ET_FLAG_HP-TPL

14 ET_FLAG-LT-TPL

15 SET_FLAG-IS_HP-

16 SET_FLAG-IS-LT-1

55 Block 55

0 START

1 OUTPUTS_OFF

2 OPEN_VALVES   HEATER_PUMP_ON

3 COOLDOWN_TIMER-1

4-MIN

4 TIMER_=_0   F

T

5 <G-LNG_DISP>   T

F

6 SET_PUMP_SPEED

7 COOLDOWN_TIMER-2

TIME=2 MIN

8 TIMER_=_0   F

T

9 TERMINAL

10 <G-LNG_DSP_1>   T

F

11 NG_PUMP_SPEED=0

51 <LER_SW_ON>   T

50 COLNT_PUMP_T-ON

F

52 NG_READY_LIT_ON

12 <LX_ON?-PRS>   F

T

P<4000?

42 COOLANT_PUMPS_ON

13 <G_PUMP_SP>   F

T

15 SET_LNG_PUMP_SPD

14 FILL_STORAGE

LX_LOP_RESTART

55 LC_TPLX_PRESSR

F

19 <PLX_PRIMED>   T   18 <G_PUMP_SP>   F   16 <LX_OFF?-PRS>

T   F

F   20 SET_LNG_PUMP_SP-

17 <G-LNG_DIS_U>   F

22 LX_LOP_INDEX+1

T

21 TRIPLEX_STANDBY   25 PUMPS_STANDBY

28 <LX_LOP_INDX>   F

T

48 SET_FLG_PRIME=T   27 TIMER-STDBY=3600

29 END-1

P<4000 PSI

30 <LX_ON?-PRS>   F

T

40 COLNT_PUMP_ON   44 <L_TEMP_SW>

F

54 TIMER>3450   F

T

45 COLNT_PUMP_OFF

P<4000   37 <L_ON?-PR=LU>   T   F

36 RESET_SYSTEM

35 NG_STANDDOWN

T

34 <ER-STDBY>   F

33 STDOWN_TRIPLEX

31 <ER-STDBY<>   F

T

TRIPLEX STOP IS BASED
AVERAGE PRESSURE
ONCE/SECOND

TRIPLEX_SHUTDOWN_CHART flowchart

- 0 START — NO VARIBLES RESET
- 1 NG_START_ON — F / T
- 2 START TPLX CHRTS — START ALARM CHARTS
- 3 NG_START_ON — F / T
- 4 STOP TRIPLEX
- 5 DISPNSNG — F / T
- 6 SHUTDWN CNG ONLY — BOILER S.D. ONLY
- 7 SHUTDOWN LNG/CNG — BLOILER S.D. AND LNG S.D. / STOP ALARM CHARTS
- 9 TIMER-CNG=1200
- 8 TIMER-CNG=1200-
- 12 NG_START_ON — T / F
- 10 NG_START_ON — T / F
- 13 TIMER-CNG=0 — F / F / T
- 11 TIMER-CNG=0 — F / T
- 14 DISPENS_ON — F / T
- 15 CNG SD COMPLETE
- 16 &CNG SD COMPLET

NUMERIC VARIABLES

NAME	TYPE	INIT.	VALUE	SECURITY	REF. COUNT
AVG_TRIPLEX_PRESSURE	FLOAT	RUN	0	0	3
CNG_Hose_1_Fill_Pressure	INT	RUN	2700	0	0
CNG_Hose_2_Fill_Pressure	INT	RUN	2700	0	0
CNG_Low_Flow_Rate	INT	RUN	0	0	0
CNG_PUMP_MODE	INT	RUN	0	0	8
CNG_Storage_End_PSI	INT	DWNLD	4900	0	1
CNG_Storage_Start_Fill_Pressure	INT	RUN	4300	0	3
COM1_CONFIG	INT	RUN	0	0	2
COM1_STATUS	INT	RUN	0	0	77
COM2_CONFIG	INT	RUN	0	0	1
COUNTER_PRIMING_TRIPLEX	INT	RUN	0	0	6
CURRENT_FUEL_FLOW	FLOAT	RUN	0	0	3
FLAG_ALARM_TRIPLEX_SYSTEM	INT	RUN	0	0	11
FLAG_COOLANT_FLOW	INT	RUN	0	0	13
FLAG_COOLANT_PUMP_FLOW_LOSS	INT	RUN	0	0	4
FLAG_FUELING_IN_PROCESS	INT	RUN	0	0	5
FLAG_H2O_HEATER_S_D__COMPLETE	INT	RUN	0	0	3
FLAG_HEATER_PUMP_FLOW_LOSS	INT	RUN	0	0	4
FLAG_INSTRUMENT_FAILURE_HP_TPX	INT	RUN	0	0	6
FLAG_INSTRUMENT_FAILURE_LT_TPX	INT	RUN	0	0	5
FLAG_LNG_DISPENSING_ON	INT	RUN	0	0	10
FLAG_LOSS_OF_PRIME_TRIPLEX	INT	RUN	0	0	4
FLAG_PRESS_ALARM__TRIPLEX	INT	RUN	0	0	5
FLAG_TEMP_ALARM_TRIPLEX	INT	RUN	0	0	6
FLAG_TRIPLEX_CHART_ON	INT	RUN	0	0	9
FLAG_WATER_HEATER_FLOW	INT	RUN	0	0	8
FLOW_INDEX_C_PUMP	INT	RUN	0	0	5
FLOW_INDEX_H20_PUMP	INT	RUN	0	0	5
FUEL_FLOW_RISING	FLOAT	RUN	0	0	2
GALLONS_DELIVERED	FLOAT	RUN	0	0	3
INDEX	INT	RUN	0	0	13
INDEX_1	INT	RUN	0	0	7
LBS_DELIVERED	FLOAT	RUN	0	0	4
LNG_METER_COUNT	INT	RUN	0	0	2
LNG_PRESSURE	FLOAT	RUN	0	0	2

NAME	TYPE	INIT.			REF. COUNT
LNG_TEMPERATURE	FLOAT	RUN	0	0	6
Loss_of_Prime	INT	RUN	0	0	4
Low_Bank_Callout_PSI	INT	RUN	3000	0	1
PRESSURE_TO_HIGH	INT	RUN	0	0	1
PREVIOUS_FUEL_FLOW	FLOAT	RUN	0	0	1
SATURATION_PRESSURE	INT	RUN	0	0	9
SATURATION_PRESSURE__10	INT	RUN	0	0	1
SATURATION_PRESSURE__15	INT	RUN	0	0	1
SATURATION_PRESSURE__5	INT	RUN	0	0	3
TABLE_TEMPERATURE	FLOAT	RUN	0	0	4
TABLE_TEMPERATURE_1	FLOAT	RUN	0	0	4
Time_Pump_Prime	INT	RUN	0	0	0
TIMER_CHECK_FUEL	DN TIMER	RUN		0	3
TIMER_CNG_STOP	DN TIMER	RUN		0	6
TIMER_COOLANT_ESD	DN TIMER	RUN		0	5
TIMER_COOLANT_PUMP_STOP_DELAY	DN TIMER	RUN		0	5
TIMER_NO_FLOW	DN TIMER	RUN		0	3
Timer_Pump_Primer	INT	RUN	100	0	1
TIMER_PUMP_PRIMING	DN TIMER	RUN		0	4
TIMER_SYSTEM_COOLDOWN	DN TIMER	RUN		0	3
TIMER_TRIPLEX_COOLDOWN	DN TIMER	RUN		0	7
TIMER_TRIPLEX_STANDBY	DN TIMER	RUN		0	7
TOTAL_TRIPLEX_PRESSURE	FLOAT	RUN	0	0	10
TRASH	INT	RUN	0	0	15

STRING VARIABLES

NAME	INIT.	WIDTH	SECURITY	REF. COUNT
BRIGHT_SCREEN	RUN	50	0	4
GALLONS_DELIVERED_DISPLAY	RUN	50	0	5
GALLONS_DELIVERED_STRING	RUN	50	0	3
LBS_DELIVERED_DISPLAY	RUN	50	0	5
LBS_DELIVERED_STRING	RUN	50	0	3
MES1_BLANK_LINE_1	RUN	50	0	4
MES1_BLANK_SCREEN	RUN	50	0	17
MES1_BLOWDOWN_TANK	RUN	50	0	4
MES1_CURNT_SAT_PRES	RUN	50	0	4
MES1_EMERGENCY_STOP	RUN	50	0	4
MES1_FUELING	RUN	50	0	4
MES1_LOSS_OF_AIR_SUPPLY	RUN	50	0	4
MES1_LOW_FUEL_SUPPLY	RUN	50	0	4
MES1_RESET_SYSTEM	RUN	50	0	4

MES1_SAT_P_B	RUN	50	0	4
MES1_SATURATE_TANK	RUN	50	0	4
MES1_SELECT_NOZZLE	RUN	50	0	4
MES1_START_FUELING	RUN	50	0	4
MES1_START_LNG_SYSTEM	RUN	50	0	4
MES1_SYSTEM_COOLDOWN	RUN	50	0	4
MES1_SYSTEM_START_UP	RUN	50	0	4
MES1_TANK_FULL	RUN	50	0	4
MES2_BLANK_LINE_2	RUN	50	0	4
MES2_EMERGENCY_STOP	RUN	50	0	4
MES2_FUELING	RUN	50	0	4
MES2_LEAK_DETECTION_ALARM	RUN	50	0	4
MES2_LOSS_OF_AIR_SUPPLY	RUN	50	0	4
MES2_LOW_FUEL_SUPPLY	RUN	50	0	4
MES2_PRIME_PUMP	RUN	50	0	4
MES2_RESET_SYSTEM	RUN	50	0	4
MES2_SAT_P_B	RUN	50	0	4
MES2_SATURATE_TANK	RUN	50	0	4
MES2_SELECT_NOZZLE	RUN	50	0	4
MES2_START_FUELING	RUN	50	0	4
MES2_START_LNG_SYSTEM	RUN	50	0	4
MES2_SYSTEM_COOLDOWN	RUN	50	0	4
MES2_TANK_FULL	RUN	50	0	4
MES3_BLOWDOWN_TANK	RUN	50	0	4
MES3_CURNT_SAT_PRES	RUN	50	0	4
MES3_EMERGENCY_STOP	RUN	50	0	4
MES3_FUELING	RUN	50	0	4
MES3_LEAK_DETECTION_ALARM	RUN	50	0	4
MES3_LOSS_OF_AIR_SUPPLY	RUN	50	0	4
MES3_LOW_FUEL_SUPPLY	RUN	50	0	4
MES3_PRIME_PUMP	RUN	50	0	4
MES3_RESET_SYSTEM	RUN	50	0	4
MES3_SAT_P_B	RUN	50	0	4
MES3_SATURATE_TANK	RUN	50	0	4
MES3_SELECT_NOZZLE	RUN	50	0	4
MES3_START_FUELING	RUN	50	0	4
MES3_START_LNG_SYSTEM	RUN	50	0	4
MES3_SYSTEM_COOLDOWN	RUN	50	0	4
MES3_SYSTEM_START_UP	RUN	50	0	4
MES4_BLOWDOWN_TANK	RUN	50	0	4

MES4_CURNT_SAT_PRES	RUN	50	0	4
MES4_EMERGENCY_STOP	RUN	50	0	4
MES4_FUELING	RUN	50	0	4
MES4_RESET_SYSTEM	RUN	50	0	4
MES4_SATURATE_TANK	RUN	50	0	4
MES4_SATURATION_PRESSURE	RUN	50	0	5
MES4_SELECT_NOZZLE	RUN	50	0	4
MES4_START_FUELING	RUN	50	0	4
MES4_START_LNG_SYSTEM	RUN	50	0	4
MES4_SYSTEM_START_UP	RUN	50	0	4
REMOVE_CURSOR	RUN	50	0	2
SAT_PRESS_DISPLAY	RUN	50	0	5
SATURATION_PRESSURE_STRING	RUN	50	0	6

NUMERIC TABLES

NAME	TYPE	LENGTH	INIT.	SECURITY	REF. COUNT
LNG_PSIG_VS_SATURATION_TEMP	FLOAT	152	RUN	0	255
LNG_TEMP_VS_LBS_CUBIC_FOOT	FLOAT	82	RUN	0	81

I/O UNITS

NAME:	*BRICK_101_DIGITAL_SIMPLE*			
DESCRIPTION:				
TYPE:	G4 Digital Local Simple	**PORT:**	Local	
ADDRESS:	101	**WATCHDOG:**	Disabled	
ENABLE:	Enabled	**SECURITY:**	0	
REFERENCE COUNT: 16				

       CHANNEL #: 0
       NAME: *VALVE_SATURATION*
       DESCRIPTION:
       TYPE: Output   **MODULE:** G4OAC5: 12 - 140 VAC
       FEATURES: None   **DEFAULT:** Last
       WATCHDOG: Disabled   **ENABLE:** Enabled
       SECURITY: 0   **REFERENCE COUNT:** 11

       CHANNEL #: 1
       NAME: *VALVE_COIL_INLET*
       DESCRIPTION:
       TYPE: Output   **MODULE:** G4OAC5: 12 - 140 VAC
       FEATURES: None   **DEFAULT:** Last
       WATCHDOG: Disabled   **ENABLE:** Enabled
       SECURITY: 0   **REFERENCE COUNT:** 15

       CHANNEL #: 2
       NAME: *VALVE_PRESS_COLLAPSE*
       DESCRIPTION:
       TYPE: Output   **MODULE:** G4OAC5: 12 - 140 VAC
       FEATURES: None   **DEFAULT:** Last
       WATCHDOG: Disabled   **ENABLE:** Enabled
       SECURITY: 0   **REFERENCE COUNT:** 22

```
CHANNEL #:      3
NAME:           VALVE_RECIRCULATION__LNG_
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 22


CHANNEL #:      4
NAME:           VALVE_PRESSURE_BUILDING
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 15


CHANNEL #:      5
NAME:           VALVE_FUEL_DELIVERY__LNG_
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 9


CHANNEL #:      6
NAME:           VALVE_SUCTION__LOW_PRESS_PUMP_
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 10


CHANNEL #:      7
NAME:           LIGHT_MANUAL_RESET
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 5


CHANNEL #:      8
NAME:           LIGHT_EMERGENCY_SHUTDOWN
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 3


CHANNEL #:      9
NAME:           LIGHT_LOW_FUEL_LEVEL
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 3


CHANNEL #:      10
NAME:           LIGHT_LOW_AIR_SUPPLY
DESCRIPTION:
TYPE:           Output              MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 6


CHANNEL #:      11
NAME:           SWITCH_MANUAL_RESET
DESCRIPTION:
TYPE:           Input               MODULE:             G4IAC5: 90 - 140 VDC/VAC
FEATURES:       None                DEFAULT:            Last
WATCHDOG:       Disabled            ENABLE:             Enabled
SECURITY:       0                   REFERENCE COUNT: 4


CHANNEL #:      12
NAME:           SWITCH_START__LNG_
DESCRIPTION:
```

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 11

CHANNEL #:   13
NAME: *SWITCH_STOP__LNG_*
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 1

CHANNEL #:   14
NAME: *SWITCH_EMERGENCY_STOP__LNG_*
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 4

CHANNEL #:   15
NAME: *SWITCH_START_FUELING__LNG_*
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 2

NAME: *BRICK_102_DIGITAL*
DESCRIPTION:

TYPE:	G4 Digital Multifunction	PORT:	Local
ADDRESS:	102	WATCHDOG:	Disabled
ENABLE:	Enabled	SECURITY:	0
REFERENCE COUNT: 16			

CHANNEL #:   0
NAME: *VALVE_NOZZLE_SELECTION__LNG_*
DESCRIPTION:

TYPE:	Output	MODULE:	G4OAC5: 12 - 140 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 7

CHANNEL #:   1
NAME: *SWITCH_START_SATURATION*
DESCRIPTION:

TYPE:	Input	MODULE:	G4IDC5: 10 - 32 VDC/12-32 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 2

CHANNEL #:   2
NAME: *SWITCH_BOILER_ON___LOW_ON_*
DESCRIPTION:

TYPE:	Input	MODULE:	G4IDC5: 10 - 32 VDC/12-32 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 2

CHANNEL #:   3
NAME: *SWITCH_EXTERNAL_ALARM_OUTPUT*
DESCRIPTION:

TYPE:	Output	MODULE:	G4OAC5: 12 - 140 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT: 0

CHANNEL #:   4
NAME: *SWITCH_LEAK_DETECTION_INPUT*
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled

SECURITY:	0	REFERENCE COUNT:	2

CHANNEL #:   5
NAME: COUNTER_LNG_FLOW_METER
DESCRIPTION:

TYPE:	Input	MODULE:	G4IDC5K: 2.5 - 16 VDC
FEATURES:	Counter	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	3

CHANNEL #:   6
NAME: SWITCH_PERMISSION
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	0

CHANNEL #:   7
NAME: SWITCH_ACKNOWLEDGEMENT
DESCRIPTION:

TYPE:	Output	MODULE:	G4OAC5: 12 - 140 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	4

CHANNEL #:   8
NAME: SWITCH_MICROMOTION__18
DESCRIPTION:

TYPE:	Output	MODULE:	G4ODC5R: Form A Relay (NO)
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	2

CHANNEL #:   9
NAME: SWITCH_MICROMOTION__19
DESCRIPTION:

TYPE:	Output	MODULE:	G4ODC5R: Form A Relay (NO)
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	2

CHANNEL #:   10
NAME: SWITCH_LOW_FUEL_LEVEL_ALARM
DESCRIPTION:

TYPE:	Input	MODULE:	G4IDC5: 10 - 32 VDC/12-32 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	2

CHANNEL #:   11
NAME: SWITCH_LOW_AIR_SUPPLY
DESCRIPTION:

TYPE:	Input	MODULE:	G4IDC5: 10 - 32 VDC/12-32 VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	2

CHANNEL #:   12
NAME: SWITCH_NOZZLE_SELECT__LNG_
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	1

CHANNEL #:   13
NAME: SWITCH_CNG_SYSTEM_ON_OFF
DESCRIPTION:

TYPE:	Input	MODULE:	G4IAC5: 90 - 140 VDC/VAC
FEATURES:	None	DEFAULT:	Last
WATCHDOG:	Disabled	ENABLE:	Enabled
SECURITY:	0	REFERENCE COUNT:	5

CHANNEL #:   14

```
          NAME:              SWITCH_TRIPLEX_LOSS_OF_PRIME
          DESCRIPTION:
          TYPE:              Input          MODULE:            G4IAC5: 90 - 140 VDC/VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 1


          CHANNEL #:         15
          NAME:              SWITCH_COOLANT_PUMP_FLOW
          DESCRIPTION:
          TYPE:              Input          MODULE:            G4IDC5: 10 - 32 VDC/12-32 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 1
```

```
NAME:              BRICK_103_DIGITAL_SIMPLE
DESCRIPTION:
TYPE:              G4 Digital Local Simple       PORT:        Local
ADDRESS:           103                           WATCHDOG:    Disabled
ENABLE:            Enabled                       SECURITY:    0
REFERENCE COUNT: 16
```

```
          CHANNEL #:         0
          NAME:              LIGHT_INSTRUMENT_FAILURE
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 9


          CHANNEL #:         1
          NAME:              LIGHT_CNG_SYSTEM_READY
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 10


          CHANNEL #:         2
          NAME:              LIGHT_HIGH_GAS_DISCHARGE_PRESS
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 9


          CHANNEL #:         3
          NAME:              LIGHT_LOW_GAS_DISCHARGE_TEMP
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 9


          CHANNEL #:         4
          NAME:              LIGHT_LOSS_OF_COOLANT_FLOW
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 5


          CHANNEL #:         5
          NAME:              LIGHT_LOSS_OF_PRIME
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
          FEATURES:          None           DEFAULT:           Last
          WATCHDOG:          Disabled       ENABLE:            Enabled
          SECURITY:          0              REFERENCE COUNT: 5


          CHANNEL #:         6
          NAME:              LIGHT_LEAK_DETECTOR_ALARM
          DESCRIPTION:
          TYPE:              Output         MODULE:            G4OAC5: 12 - 140 VAC
```

```
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 2


CHANNEL #:      7
NAME:           LIGHT_CAUTION
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 10


CHANNEL #:      8
NAME:           VALVE_ODORANT_PUMP
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 9


CHANNEL #:      9
NAME:           VALVE_TRIPLEX_RECIRCULATION
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 20


CHANNEL #:      10
NAME:           VALVE_TRIPLEX_PRIMING
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 13


CHANNEL #:      11
NAME:           VALVE_TRIPLEX_SUCTION
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 12


CHANNEL #:      12
NAME:           PUMP_WATER_HEATER
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 14


CHANNEL #:      13
NAME:           PUMP_COOLANT
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 17


CHANNEL #:      14
NAME:           PUMP_TRIPLEX
DESCRIPTION:
TYPE:           Output            MODULE:             G4OAC5: 12 - 140 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 18


CHANNEL #:      15
NAME:           SWITCH_WATER_HEATER_PUMP_FLOW
DESCRIPTION:
TYPE:           Input             MODULE:             G4IDC5: 10 - 32 VDC/12-32 VAC
FEATURES:       None              DEFAULT:            Last
WATCHDOG:       Disabled          ENABLE:             Enabled
SECURITY:       0                 REFERENCE COUNT: 1
```

```
NAME:              BRICK_104_ANALOG
DESCRIPTION:
TYPE:              G4 Analog Multifunction      PORT:        Local
ADDRESS:           104                          WATCHDOG:    Disabled
ENABLE:            Enabled                      SECURITY:    0
REFERENCE COUNT: 8

        CHANNEL #:           0
        NAME:                OUTPUT_LNG_PUMP_SPEED__LNG_
        DESCRIPTION:
        TYPE:                Output        MODULE:            G4DA3: 4 - 20 mA
        DEFAULT:             No
        UNITS:               MA            ENABLE:            Enabled
        WATCHDOG:            Disabled
        SECURITY:            0             REFERENCE COUNT:   27

        CHANNEL #:           1
        NAME:                INPUT_LNG_FLOW_RATE
        DESCRIPTION:
        TYPE:                Input         MODULE:            G4AD3: 4 - 20 mA
        DEFAULT:             No
        UNITS:               LBS/MIN       ENABLE:            Enabled
        LOWER REAL READING:  4.000         UPPER REAL READING:    20.000
        LOWER SCALED READING:0.000         UPPER SCALED READING:  141.000
        ZERO-SCALE VALUE:    0.000         FULL-SCALE VALUE:      141.000
        WATCHDOG:            Disabled
        SECURITY:            0             REFERENCE COUNT:   2

        CHANNEL #:           2
        NAME:                SENSOR_LNG_STORAGE_TEMPERATURE
        DESCRIPTION:
        TYPE:                Input         MODULE:            G4AD3: 4 - 20 mA
        DEFAULT:             No
        UNITS:               DEGREES F     ENABLE:            Enabled
        LOWER REAL READING:  4.000         UPPER REAL READING:    20.000
        LOWER SCALED READING:-280.000      UPPER SCALED READING:  -180.000
        ZERO-SCALE VALUE:    -280.000      FULL-SCALE VALUE:      -180.000
        WATCHDOG:            Disabled
        SECURITY:            0             REFERENCE COUNT:   2

        CHANNEL #:           3
        NAME:                SENSOR_LNG_BOTTOM_TANK_PRESS
        DESCRIPTION:
        TYPE:                Input         MODULE:            G4AD3: 4 - 20 mA
        DEFAULT:             No
        UNITS:               PSI           ENABLE:            Enabled
        LOWER REAL READING:  4.000         UPPER REAL READING:    20.000
        LOWER SCALED READING:0.000         UPPER SCALED READING:  300.000
        ZERO-SCALE VALUE:    0.000         FULL-SCALE VALUE:      300.000
        WATCHDOG:            Disabled
        SECURITY:            0             REFERENCE COUNT:   7

        CHANNEL #:           4
        NAME:                SENSOR_TRIPLEX_DISCHARGE_PRESS
        DESCRIPTION:
        TYPE:                Input         MODULE:            G4AD3: 4 - 20 mA
        DEFAULT:             No
        UNITS:               PSI           ENABLE:            Enabled
        LOWER REAL READING:  4.000         UPPER REAL READING:    20.000
        LOWER SCALED READING:0.000         UPPER SCALED READING:  5000.000
        ZERO-SCALE VALUE:    0.000         FULL-SCALE VALUE:      5000.000
        WATCHDOG:            Disabled
        SECURITY:            0             REFERENCE COUNT:   1

        CHANNEL #:           5
        NAME:                SENSOR_CNG_DISCHARGE_TEMP
        DESCRIPTION:
        TYPE:                Input         MODULE:            G4AD3: 4 - 20 mA
        DEFAULT:             No
        UNITS:               DEGREES F     ENABLE:            Enabled
        LOWER REAL READING:  4.000         UPPER REAL READING:    20.000
        LOWER SCALED READING:-50.000       UPPER SCALED READING:  150.000
        ZERO-SCALE VALUE:    -50.000       FULL-SCALE VALUE:      150.000
```

```
WATCHDOG:            Disabled
SECURITY:            0                REFERENCE COUNT:      8


    CHANNEL #:       6
    NAME:            SENSOR_BANK_PRESS
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD3: 4 - 20 mA
    DEFAULT:         No
    UNITS:           PSI              ENABLE:               Enabled
    LOWER REAL READING:   4.000       UPPER REAL READING:   20.000
    LOWER SCALED READING: 0.000       UPPER SCALED READING: 5000.000
    ZERO-SCALE VALUE:     0.000       FULL-SCALE VALUE:     5000.000
    WATCHDOG:        Disabled
    SECURITY:        0                REFERENCE COUNT:      19


    CHANNEL #:       7
    NAME:            SENSOR_HIGH_PRESS_CNG_STORAGE
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD6: 0 - 5 VDC
    DEFAULT:         No
    UNITS:           VDC              ENABLE:               Enabled
    LOWER REAL READING:   0.000       UPPER REAL READING:   5.000
    LOWER SCALED READING: 0.000       UPPER SCALED READING: 7100.000
    ZERO-SCALE VALUE:     0.000       FULL-SCALE VALUE:     7100.000
    WATCHDOG:        Disabled
    SECURITY:        0                REFERENCE COUNT:      0
```

```
NAME:            BRICK_105_ANALOG
DESCRIPTION:
TYPE:            G4 Analog Multifunction       PORT:        Local
ADDRESS:         5                             WATCHDOG:    Disabled
ENABLE:          Enabled                       SECURITY:    0
REFERENCE COUNT: 5


    CHANNEL #:       0
    NAME:            LNG_Tank_Level
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD3: 4 - 20 mA
    DEFAULT:         No
    UNITS:           mA               ENABLE:               Enabled
    WATCHDOG:        Disabled
    SECURITY:        0                REFERENCE COUNT:      0


    CHANNEL #:       1
    NAME:            CNG_Hose_1_Pressure
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD3: 4 - 20 mA
    DEFAULT:         No
    UNITS:           mA               ENABLE:               Enabled
    WATCHDOG:        Disabled
    SECURITY:        0                REFERENCE COUNT:      0


    CHANNEL #:       2
    NAME:            CNG_Hose_2_Pressure
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD3: 4 - 20 mA
    DEFAULT:         No
    UNITS:           mA               ENABLE:               Enabled
    WATCHDOG:        Disabled
    SECURITY:        0                REFERENCE COUNT:      0


    CHANNEL #:       3
    NAME:            CNG_Hose_1_Flow
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD3: 4 - 20 mA
    DEFAULT:         No
    UNITS:           mA               ENABLE:               Enabled
    WATCHDOG:        Disabled
    SECURITY:        0                REFERENCE COUNT:      0


    CHANNEL #:       4
    NAME:            CNG_Hose_2_Flow
    DESCRIPTION:
    TYPE:            Input            MODULE:               G4AD3: 4 - 20 mA
```

DEFAULT:	No		
UNITS:	mA	ENABLE:	Enabled
WATCHDOG:	Disabled		
SECURITY:	0	REFERENCE COUNT:	0

NAME: BRICK_106_DIGITAL
DESCRIPTION:
TYPE: G4 Digital Multifunction   PORT: Local
ADDRESS: 6   WATCHDOG: Disabled
ENABLE: Enabled   SECURITY: 0
REFERENCE COUNT: 7

```
        CHANNEL #:      0
        NAME:           CNG_Hose_1_Authorized
        DESCRIPTION:
        TYPE:        Input          MODULE:            G4IAC5: 90 - 140 VDC/VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0

        CHANNEL #:      1
        NAME:           CNG_Hose_2_Authorized
        DESCRIPTION:
        TYPE:        Input          MODULE:            G4IAC5: 90 - 140 VDC/VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0

        CHANNEL #:      2
        NAME:           HS1_Bank_Valve
        DESCRIPTION:
        TYPE:        Output         MODULE:            G4OAC5: 12 - 140 VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0

        CHANNEL #:      3
        NAME:           HS2_Bank_Valve
        DESCRIPTION:
        TYPE:        Output         MODULE:            G4OAC5: 12 - 140 VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0

        CHANNEL #:      4
        NAME:           HS1_Disp_Valve
        DESCRIPTION:
        TYPE:        Output         MODULE:            G4OAC5: 12 - 140 VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0

        CHANNEL #:      5
        NAME:           HS2_Disp_Valve
        DESCRIPTION:
        TYPE:        Output         MODULE:            G4OAC5MA: 12 - 140 VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0

        CHANNEL #:      6
        NAME:           Direct_Fill_Valve
        DESCRIPTION:
        TYPE:        Output         MODULE:            G4OAC5MA: 12 - 140 VAC
        FEATURES:    None           DEFAULT:           Last
        WATCHDOG:    Disabled       ENABLE:            Enabled
        SECURITY:    0              REFERENCE COUNT:   0
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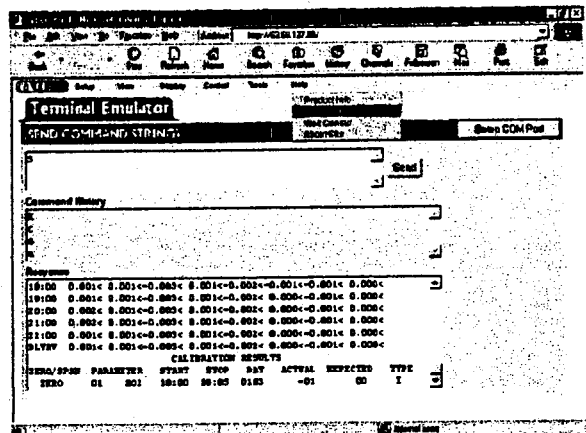
Attachment Q
Web Server and Pages

CONCUR www

CyberSerial

Y2K BUSTER

Web Enable Your Equipment

Virtual Data Interface

CyberSerial
Thin Internet Server

Description:

The CyberSerial™ is a thin Internet application server for directly accessing serial devices using the Internet. It provides a direct link to serial systems, devices and equipment using a browser based terminal emulator.

The CyberSerial, based on Concur's CyberNode thin servers, is architected for industrial and remote monitoring applications. The CyberNode's built-in web hosting capability allows serial devices to be accessed over a secure web site. Sites are built using standard HTML, Active X controls and Java applets. The node can be configured and viewed on standard web browsers over a secure network connection.

The CyberSerial provides a low cost network friendly solution for monitoring and controlling information directly from serial devices, and ports on systems and equipment over a plant intranet or the Internet. Support for 2, 6, or 10 independent serial ports with options for RS232, RS485 and RS422 are available.

Includes:
- Web Site / Server
- Event Logging
- Virtual Terminal Interface

Other Applications Available:
- CyberDigital
- CyberEnvironmental
- CyberAnalog
- CyberModbus
- Custom OEM and Engineered Solutions

Specifications:
- Serial Port Options
  - RS232 - 2, 6, and 10 ports
  - RS422 - 2 or 4 ports
  - RS485 - 2 or 4 ports
  - LPT - 1 or 2 ports
  - UARTS - 8250 and 16550
  - Baud Rates - 300 to 115200
  - Data Bits - 6, 7 or 8
  - Parity -None, Even, Odd
- Network Communications
  - TCP/IP (Ethernet) or PPP (Modem)
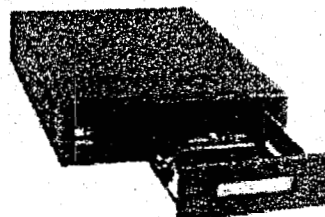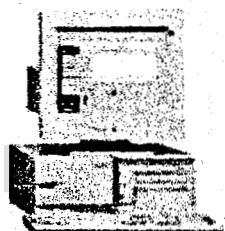
Process Control

Typical Application

Plant Control Solutions

interface with Thin-Web Server
using TCP/IP data access

remote control using
a PC's browser

easy integration with
total plant control solutions

Advantages

- *Technical*
- *Financial*

Send mail to webmaster@concursys.com with questions or comments about this web site.
Last modified: November 28, 1999

Parijat ActiveX/32 for OPTO22
MISTIC Serial Master

Properties - OMistic1	
OMistic1 OMistic	
Alphabetic	**Categorized**
(About)	
(Custom)	
(Name)	OMistic1
Busy	False
CdbName	
CdbPath	
CommandReply	
ControllerCommand	
ControllerName	
DataWords	1
Enabled	False
Index	
Left	2400
MemType	0 - Digital
PLCFunction	0 - ReadMem
PollingInterval	0
Result	0
StartAddr	0
Tag	
TagCntr	0
TimeOut	1000
Top	240
TransactionTime	0

PCI-OPTOmist-ACTX

Developed using state of the art Microsoft MFC4 technology for enhanced throughput and low overhead, Parijat's industrial communication 32-bit ActiveX custom controls, acquires data from Opto22 Mistic Controllers via serial port. Read analog, digital, strings and variable type point records. Manipulate properties using our custom property sheets for utmost user-friendliness at design time. Blocks of point records may be processed simultaneously. Powerful error trapping & reporting tools are provided. Rapid exception processing is available with our CompareInfo method. ActiveX's are very fast and also do not require significant Windows resources as DDE drivers or servers do.

Methods: Refresh CompareInfo
Events: Outcome (fires when communication transaction completes)
Throughput: Microseconds order performance.
This product works with:
Microsoft Visual Basic, Visual C++/J++ , Office97, Foxpro95 or any other OLE container.
Related VBX Products: None

Features:
- No software protection keys.
- Complete context-sensitive help & built-in manual.

We also develop custom Windows products and applications with PLC's, MS Visual Basic, as well. We can also develop any ActiveX that you may need developed for a specific purpose. We also have an GUI MMI software(Visual Process) written in VB which provides basic SCADA monitoring, alarming, trending, reporting. With Visual Process, any CAD drawings, manuals, vendor data sheets, instrument spec sheets, instrument calibration sheets or any other documentation associated with control systems may also be integrated with the MMI/SCADA system to help attain the ISO9000 certification!
12/97

Parijat COMMUNICATION DRIVERS

Parijat Controlware, Inc.

"Simplifying your life with Software Solutions"

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Parijat specializes in writing communication drivers for just about any product. If you do not see your particular needs met from the above list, give us a call about other drivers that we are working on that may have not made it to this list yet. We are continually writing other drivers for a wide variety of applications.

- **PLC ActiveX 32 Bit Communication Drivers**
- **PLC DLL 32 Bit Communication Drivers**
- **PLC 16 Bit VBX Communication Drivers**

You may see the full list of the products.

To register your demo version contact Parijat for registration number.

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Parijat Controlware, Inc.

"Simplifying your life with Software Solutions"

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- Parijat SCADA/HMI Development System Literature
- Parijat Customer List
- Parijat Control System Projects
- Product Licenses
- Product Development & Run Times

PRODUCT INFORMATION
- SCADA/HMI Development System
- Productivity Enhancement Tools
- Communication Analyzers
- Special Application Tools
- PLC Communication

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- Download Parijat Demo Software

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Environmental Information Server
Monitoring Demo

Parijat Controlware, Inc.
1425 Blalock Suite 201
Houston Texas 77055
Ph: 713-935-0900
Fx: 713-935-9565

sales@parijat.com   http://www.parijat.com

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Lone Star Energy

Username

Password

Submit

| Readings | Alarms | Data | | Update |

LNG

LNG

LONE STAR ENERGY CO.
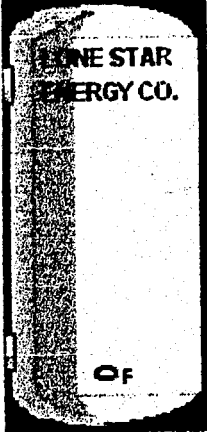
TANK	0.000
SAT	0
F	0.000

0 F

CNG
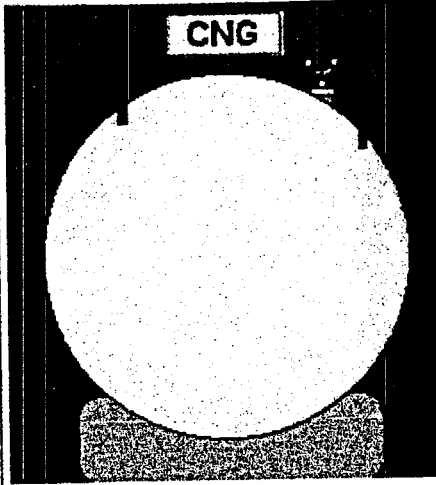
CNG

FILL START PRESSURE	0
ORDERED PRESSURE	0
STORAGE PRESSURE	0.000

FCV
Pump Speed
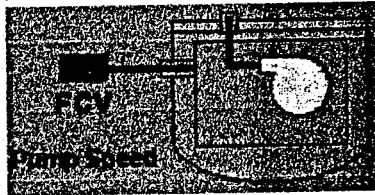
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Pump Speed	4.000

Pumping
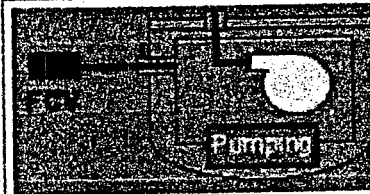
| Pressure | 0.000 |

CNG Hose 1	
PT691	0.000
FM660	0.000
Authorized	0

CNG Hose 2	
PT691	0.000
FM660	0.000
Authorized	0

LNG Dispenser	
PT691	-36.160
FM660	0

Messages

NA

| Readings | Alarms | Data |

Action	Time	Date	Name			State	Comment
Ack							

Acknowledge All   Clear All

Historic							
Time	Date	Name			State	Comment	

Clear History

| | Readings | Alarms | Data | | Update |

Select	Name	Value	Channel	Type	Features	Enable
Info	AVG_TRIPLEX_PRESSURE	4911.811	0	Variable	None	NA
Info	CNG_Storage_End_PSI	4900	0	Variable	None	NA
Info	CNG_Storage_Start_Fill_Pressure	4350	0	Variable	None	NA
Info	CURRENT_FUEL_FLOW	57.178	0	Variable	None	NA
Info	FLAG_ALARM_TRIPLEX_SYSTEM	0	0	Variable	None	NA
Info	FLAG_COOLANT_FLOW	0	0	Variable	None	NA
Info	FLAG_COOLANT_PUMP_FLOW_LOSS	0	0	Variable	None	NA
Info	FLAG_FUELING_IN_PROCESS	0	0	Variable	None	NA
Info	FLAG_HEATER_PUMP_FLOW_LOSS	0	0	Variable	None	NA
Info	FLAG_LNG_DISPENSING_ON	0	0	Variable	None	NA
Info	FLAG_LOSS_OF_PRIME_TRIPLEX	0	0	Variable	None	NA
Info	FLAG_PRESS_ALARM__TRIPLEX	0	0	Variable	None	NA
Info	FLAG_TEMP_ALARM_TRIPLEX	0	0	Variable	None	NA
Info	FLAG_WATER_HEATER_FLOW	-1	0	Variable	None	NA
Info	AVG_TRIPLEX_PRESSURE	4911.811	0	Variable	None	NA
Info	GALLONS_DELIVERED	15.597	0	Variable	None	NA
Info	LBS_DELIVERED	48.040	0	Variable	None	NA
Info	LNG_PRESSURE	105.124	0	Variable	None	NA
Info	LNG_TEMPERATURE	-123.457	0	Variable	None	NA
Info	Loss_of_Prime	4955	0	Variable	None	NA
Info	SATURATION_PRESSURE	151	0	Variable	None	NA
Info	TIMER_TRIPLEX_STANDBY	2223	0	Variable	None	NA
Info	VALVE_SATURATION	0	0	Digital_Point	None	
Info	VALVE_COIL_INLET	0	1	Digital_Point	None	
Info	VALVE_PRESS_COLLAPSE	0	2	Digital_Point	None	
Info	VALVE_RECIRCULATION__LNG_	0	3	Digital_Point	None	
Info	VALVE_PRESSURE_BUILDING	1	4	Digital_Point	None	

Info	VALVE_FUEL_DELIVERY__LNG_	0	5	Digital_Point	None	Enable
Info	VALVE_SUCTION__LOW_PRESS_PUMP_	1	6	Digital_Point	None	Enable
Info	LIGHT_MANUAL_RESET	0	7	Digital_Point	None	Enable
Info	LIGHT_EMERGENCY_SHUTDOWN	0	8	Digital_Point	None	Enable
Info	LIGHT_LOW_FUEL_LEVEL	0	9	Digital_Point	None	Enable
Info	Emergency_Dial_Out	0	10	Digital_Point	None	Enable
Info	SWITCH_MANUAL_RESET	0	11	Digital_Point	None	Enable
Info	SWITCH_START__LNG_	0	12	Digital_Point	None	Enable
Info	SWITCH_STOP__LNG_	0	13	Digital_Point	None	Enable
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Info	SWITCH_START_FUELING__LNG_	0	15	Digital_Point	None	Enable
Info	VALVE_NOZZLE_SELECTION__LNG_	0	0	Digital_Point	None	Enable
Info	SWITCH_START_SATURATION	0	1	Digital_Point	None	Enable
Info	SWITCH_BOILER_ON__LOW_ON_	0	2	Digital_Point	None	Enable
Info	SWITCH_EXTERNAL_ALARM_OUTPUT	0	3	Digital_Point	None	Enable
Info	SWITCH_LEAK_DETECTION_INPUT	0	4	Digital_Point	None	Enable
Info	COUNTER_LNG_FLOW_METER	0	5	Digital_Point	None	Enable
Info	SWITCH_PERMISSION	0	6	Digital_Point	None	Enable
Info	SWITCH_ACKNOWLEDGEMENT	0	7	Digital_Point	None	Enable
Info	SWITCH_MICROMOTION__18	0	8	Digital_Point	None	Enable
Info	SWITCH_MICROMOTION__19	0	9	Digital_Point	None	Enable
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Info	SWITCH_LOW_AIR_SUPPLY	1	11	Digital_Point	None	Enable
Info	SWITCH_NOZZLE_SELECT__LNG_	0	12	Digital_Point	None	Enable
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Info	SWITCH_TRIPLEX_LOSS_OF_PRIME	0	14	Digital_Point	None	Enable
Info	SWITCH_COOLANT_PUMP_FLOW	1	15	Digital_Point	None	Enable
Info	LIGHT_INSTRUMENT_FAILURE	0	0	Digital_Point	None	Enable
Info	LIGHT_CNG_SYSTEM_READY	1	1	Digital_Point	None	Enable
Info	LIGHT_HIGH_GAS_DISCHARGE_PRESS	0	2	Digital_Point	None	Enable
Info	LIGHT_LOW_GAS_DISCHARGE_TEMP	0	3	Digital_Point	None	Enable

Info	LIGHT_LOSS_OF_COOLANT_FLOW	0	4	Digital_Point	None	Enable
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Info	LIGHT_CAUTION	0	7	Digital_Point	None	Enable
Info	VALVE_ODORANT_PUMP	0	8	Digital_Point	None	Enable
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Info	VALVE_TRIPLEX_SUCTION	1	11	Digital_Point	None	Enable
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Info	PUMP_COOLANT	0	13	Digital_Point	None	Enable
Info	PUMP_TRIPLEX	0	14	Digital_Point	None	Enable
Info	SWITCH_WATER_HEATER_PUMP_FLOW	1	15	Digital_Point	None	Enable
Info	OUTPUT_LNG_PUMP_SPEED__LNG_	4.000	0	Analog_Point	None	Enable
Info	INPUT_LNG_FLOW_RATE	10.362	1	Analog_Point	None	Enable
Info	SENSOR_LNG_STORAGE_TEMPERATURE	-123.457	2	Analog_Point	None	Enable
Info	SENSOR_LNG_BOTTOM_TANK_PRESS	105.344	3	Analog_Point	None	Enable
Info	SENSOR_TRIPLEX_DISCHARGE_PRESS	4988.978	4	Analog_Point	None	Enable
Info	SENSOR_CNG_DISCHARGE_TEMP	70.557	5	Analog_Point	None	Enable
Info	SENSOR_BANK_PRESS	4747.221	6	Analog_Point	None	Enable
Info	SENSOR_HIGH_PRESS_CNG_STORAGE	0.000	7	Analog_Point	None	Enable
Info	LNG_Tank_Level	0.000	0	Analog_Point	None	Enable
Info	CNG_Hose_1_Pressure	0.000	1	Analog_Point	None	Enable
Info	CNG_Hose_2_Pressure	0.000	2	Analog_Point	None	Enable
Info	CNG_Hose_1_Flow	0.000	3	Analog_Point	None	Enable
Info	CNG_Hose_2_Flow	0.000	4	Analog_Point	None	Enable
Info	CNG_Hose_1_Authorized	0	0	Digital_Point	None	Enable
Info	CNG_Hose_2_Authorized	0	1	Digital_Point	None	Enable
Info	HS1_Bank_Valve	0	2	Digital_Point	None	Enable
Info	HS2_Bank_Valve	0	3	Digital_Point	None	Enable
Info	HS1_Disp_Valve	0	4	Digital_Point	None	Enable
Info	HS2_Disp_Valve	0	5	Digital_Point	None	Enable

| Info | Direct_Fill_Valve | 0 | 4 | Digital_Point | None | |

Attachment R
LNG Nozzles

NOTES: 1. MEDIA: LIQUIFIED NATURAL GAS.

2. TEMPERATURE RANGE: +160°F TO -259°F.

3. PRESSURES: 500 PSI MAX OPERATING
1500 PSI MIN BURST.

4. RATED FLOW: 50 GPM

5. AIR INCLUSION: 4.5CC MAX PER CONNECT

6. LIQUID SPILLAGE: 2.4CC MAX PER DISCONNECT

7. MATERIALS: HOUSINGS AND HANDLES - ALUMINUM ALLOY
RECEPTACLE FLANGE - ALUMINUM BRONZE
COLLAR AND INTERNAL PARTS - STAINLESS STEEL
SEALS AND BEARINGS - PTFE AND UHMW POLYETHYLENE

8. SEPARATE CONNECT AND VALVE FUNCTIONS
NOZZLE VALVE CANNOT BE OPENED UNTIL NOZZLE IS FULLY CONNECTED TO THE RECEPTACLE.
NOZZLE CANNOT BE DISCONNECTED UNTIL VALVES ARE FULLY CLOSED. COUPLING INTERFACE
IS VENTED DURING CONNECT/DISCONNECT OPERATION

9. OPERATION:
9.1 PUSH NOZZLE ONTO RECEPTACLE TO UNLOCK COLLAR.
9.2 ROTATE COLLAR 30° CLOCKWISE TO COUPLE NOZZLE AND UNLOCK VALVE HANDLE
9.3 ROTATE VALVE HANDLE 195° CLOCKWISE TO SEAL INTERFACE AND OPEN VALVES.
9.4 DISCONNECT IN REVERSE SEQUENCE.

10. INTERFACE SEAL IS FIELD REPLACEABLE.

11. NOZZLE INLET PORT IS EQUIPED WITH A 360° SWIVEL.
ROTATION OF SWIVEL MAY BE LIMITED BY NITROGEN PURGE HOSE.

12. WEIGHT: NOZZLE - 9.20 POUNDS
RECEPTACLE - 2.20 POUNDS
CAP - .28 POUNDS

COLLAR HANDLE DISCONNECTED POSITION

COLLAR HANDLE CONNECTED POSITION

NITROGEN PURGE PORT HOSEBARS FOR 1/4 INCH I.D. HOSE

8.91

1.38 HEX

30°

4.19

.88 DIA TYP

1 INCH 37° FLARED TUBE FITTING

VALVE HANDLE SHUT POSITION

VALVE HANDLE OPEN POSITION

RECEPTACLE FACE

8.94

9.57

.54

.99

NOZZLE DUST CAP 1169-65

1.02

45°

NOZZLE 1169-608

4.75

RECEPTACLE MOUNTING SURFACE

1.56

2.44

3.02

1-11 1/2 NPTF PORT

RECEPTACLE 1169-63

ATTACH LANYARD TAB TO THIS SIDE OF FLANGE ONLY

.81 TYP

1.62

1/4-28 MOUNTING BOLTS 3 PLACES

1.41 TYP

1.88 HEX

LNG ONLY
REMOVE
PUSH AND TURN
LOCK
Parker

4.00 DIA

RECEPTACLE DUST CAP 1169-66

J. C. Carter Company

Single Line Liquefied Natural Gas Fueling Coupling

Models 50 E700A and 50 E701
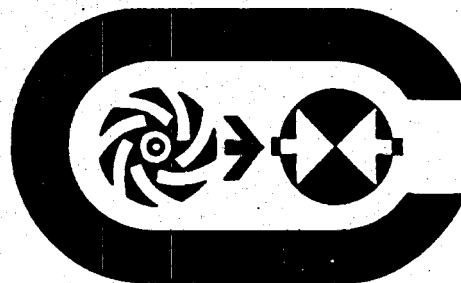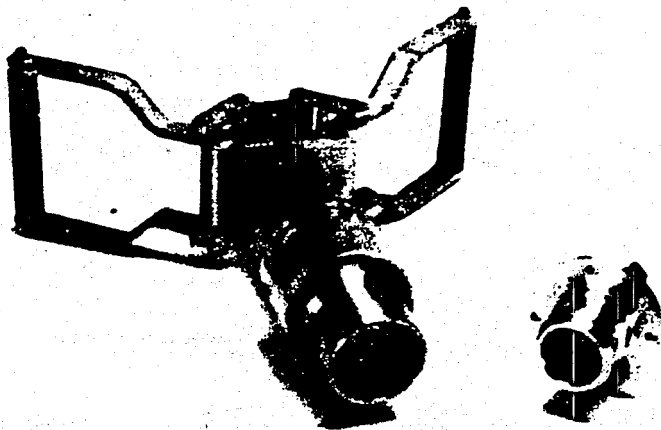
J.C. Carter Company, Inc
671 West 17th Street
Costa Mesa, CA 92627

Description

J. C. Carter's Single Line Fueling Coupling is designed for NO-VENT fueling facilities. The Nozzle (Model 50E701) attaches to the fuel hose. The nozzle is maneuvered and actuated ʾng the double handled scissors linkage. The receptacle ⌣del 50E700A) mounts on the LNG fueled vehicle. Both the nozzle and receptacle incorporate independent shut-off valves. A built in breakaway feature prevents LNG flow from either the nozzle or receptacle if forced separation occurs. A dust cap (C01491) is available to prevent debris from entering the receptacle when not in use.

Features

J. C. Carter's Single Line LNG Fueling Coupling is designed to meet the time conscious fueling tasks of fleet operators and includes the following features:

- No nitrogen purging is required for proper operation
- One motion mating for simple operation
- Built-in compression fitting on receptacle allows simple, inexpensive vehicle installation
- Receptacle may be used as a primary shut-off valve
- Patented interface seal arrangement prevents liquid leakage while fueling
- Modular construction for simple field maintenance
- Rugged design to survive harsh fleet fueling facility environment
- Ice Breaker™ technology for Freeze-On-Free fueling

Typical Performance Specifications

Fluid Compatibility:	LNG, Methane, LN$_2$
Max. Refueling Pressure:	250 psig
Max. Working Pressure:	500 psig
Burst Pressure:	1500 psig
Rated Flow:	50 gpm
Receptacle Weight:	3 lbs
Nozzle Weight:	12 lbs
Operating Temperature:	-320°F to 120°F
Storage Temperature:	-60°F to 120°F
Spillage on Demating:	20 cc
Leakage while Fueling:	None
Average Time to Mate:	<3 sec
Average Time to Demate:	<2 sec
⌣ ated Life:	36,500 cycles between major maintenance service
⌣zle Connection:	1.00" female ports will accept MS33649-16 fittings
Receptacle Connection:	3/4" compression tube fitting
Standards:	Will satisfy NFPA and SAE requirements

LNG COUPLINGS
THE ICE BREAKERS™
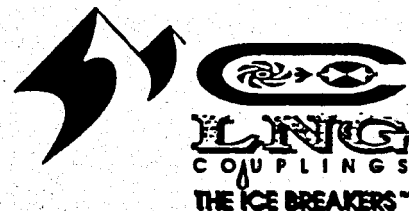
J.C. Carter Company

Small Single Line Liquefied Natural Gas Fueling Coupling

Models 50 E721 and 50 E722
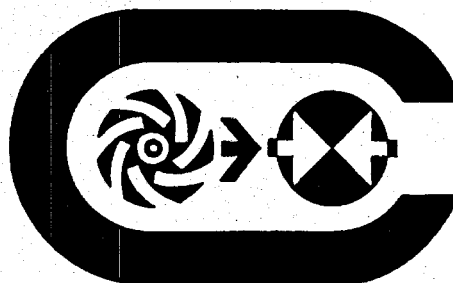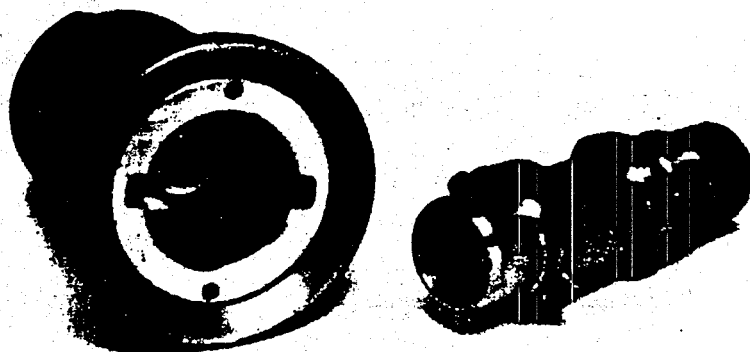
J.C. Carter Company, Inc
671 West 17th Street
Costa Mesa, CA 92627

Description

J. C. Carter's Small Single Line Fueling Coupling is designed for NO-VENT fueling facilities. The Nozzle (Model 50 E722) attaches to the fuel hose. The nozzle is connected to the receptacle and actuated through a 1/4 turn mechanism. The receptacle (Model 50 E721) mounts on the LNG fueled vehicle. Both the nozzle and receptacle incorporate independent shut-off valves. A built in breakaway feature prevents LNG flow from either the nozzle or receptacle if forced separation occurs.

Features

J.C. Carter's Single Line LNG Fueling Coupling is designed to meet the time conscious fueling tasks of fleet operators and includes the following features:

- One motion mating for simple operation
- Compact design results in simple installation
- Diametral seals for LEAK-FREE fueling
- Ice Breaker™ interface technology for Freeze-On-Free fueling
- Rugged design to survive harsh fleet fueling facility environment
- Modular construction for simple maintenance
- No external purge requirement reduces operating costs

Typical Performance Specifications

Fluid Compatibility:	LNG, Methane. LN$_2$, many other cryogens
Max. Refueling Pressure:	250 psig
Max. Working Pressure:	500 psig
Burst Pressure:	1500 psig
Rated Flow:	10 gpm
Receptacle Weight:	0.4 lbs
Nozzle Weight:	1.2 lbs
Operating Temperature:	-320°F to 120°F
Storage Temperature:	-60°F to 120°F
Spillage on Demating:	5 cc
Leakage while Fueling:	None
Average Time to Mate:	<3 sec
Average Time to Demate:	.2 sec
Estimated Life:	36,500cycles between major maintenance service
Standards:	Will satisfy NFPA and SAE requirements

50 GPM SEAL REPLACEMENT KIT

CAUTION: Read instructions completely before attempting to replace seal. Failure to do so can result in personal injury.

If nozzle is disconnected from the LNG fueling system, do not allow water or other contaminants to enter the internal mechanism of this coupling.

Tools Required
Standard external type pliers: "1-1/8" retaining ring

CAUTION: Under no circumstances should the nozzle be capable of flowing during the seal replacement procedure.

1) Place nozzle assembly in a vertical position on a clean work area with the handles fully extended, see Figure "A".

2) Remove the retaining ring from nozzle shroud. Discard the used ring as damage may occur during disassembly.

3) Once the retaining ring is removed, remove and discard both retainer seal and spring energized seal.

4) Wipe clean the sealing surface on the nozzle shroud, install the new spring energized seal in proper orientation shown. Failure to install the seal in this orientation will result in leakage during mating operation.

5) Place the seal retainer over the seal (Also note orientation) and reinstall the retaining ring. Note: Be careful not to overextend the retaining rings during assembly. The retaining rings should fit securely into grooves. Push the retaining ring into groove to fully secure seal and retainer. Verify visually that the retaining ring is seated into shroud groove.
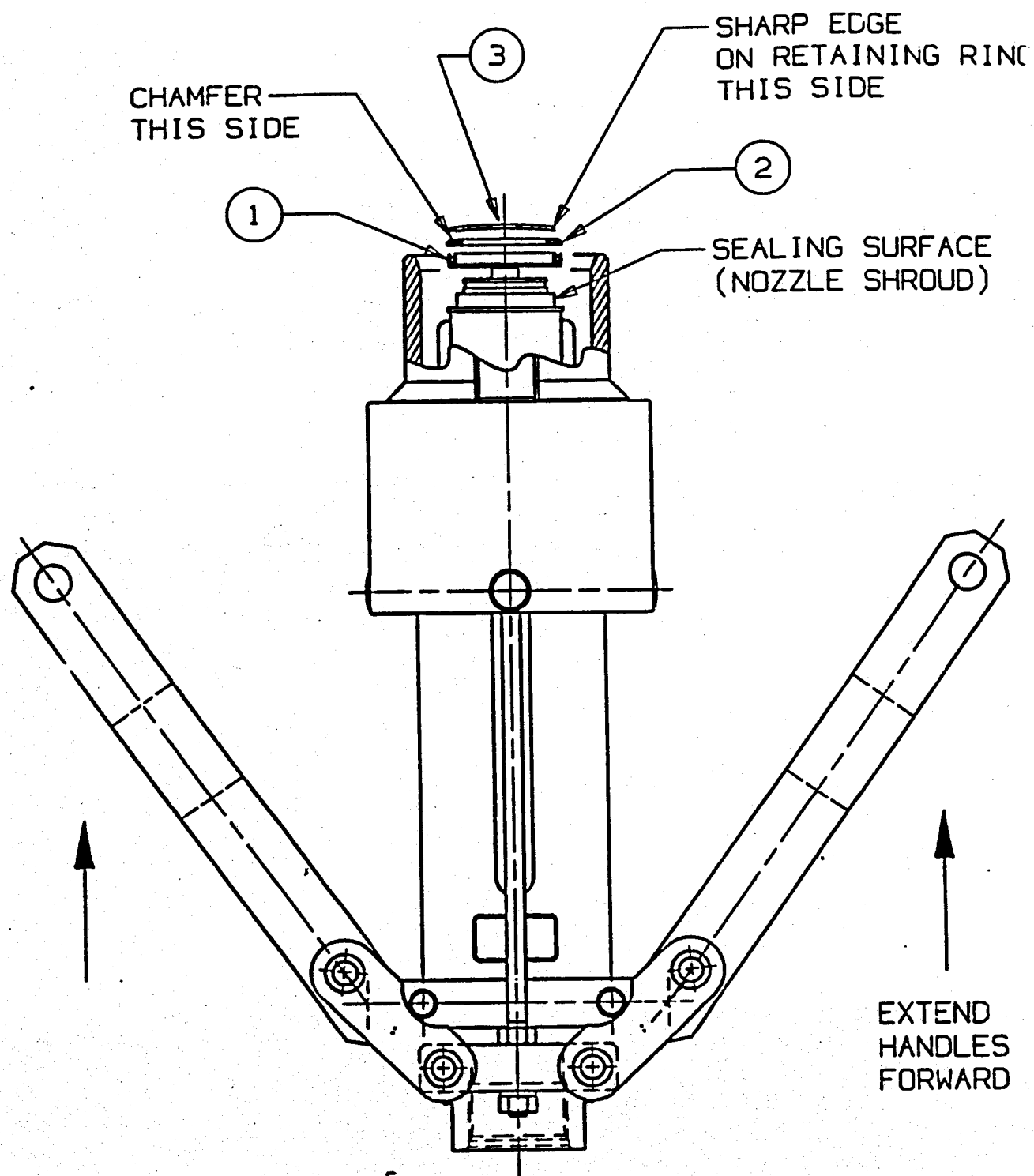
MODEL 50E701

CHAMFER
THIS SIDE

SHARP EDGE
ON RETAINING RING
THIS SIDE

SEALING SURFACE
(NOZZLE SHROUD)

EXTEND
HANDLES
FORWARD

FIGURE: A

QTY	PART NUMBER	DESCRIPTION	FIND NO.
1	B78705-003	SPRING ENERGIZED SEAL	1
1	B84398-001	SEAL RETAINER	2
1	B91877SS112	RETAINING RING	3

50 GPM SEAL REPLACEMENT KIT

MODEL 50E7C