CRYOGENIC INDUSTRIES
FROSTBYTE
A NEWSLETTER FROM CRYOGENIC INDUSTRIES FALL 2011

Efficient Reduction of LIN Production in a Waste Expansion Plant

The TGN series plants produce high purity gaseous nitrogen (GAN) and a small amount (5-10% of GAN) of liquid nitrogen (LIN) by cryogenic distillation of atmospheric air via a waste expansion refrigeration cycle. This expansion cycle is common and cost effective, however, it inherently produces a fixed amount of refrigeration. The fixed amount of refrigeration is set by the customer's pipeline pressure, nitrogen recovery, and nitrogen required for regeneration. Normally there is more refrigeration than required to make up for heat leak, and this excess amount determines how much LIN is produced.

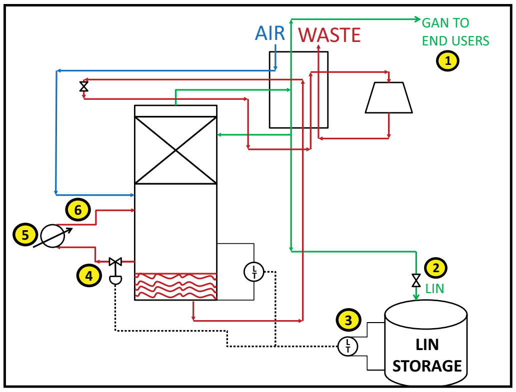


Figure 1: Waste Expansion Cycle

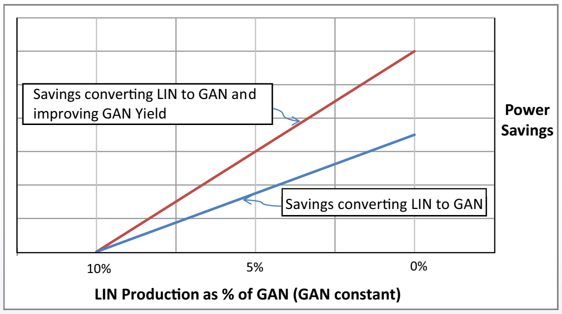


Figure 2: Power Savings As LIN Production Decreases

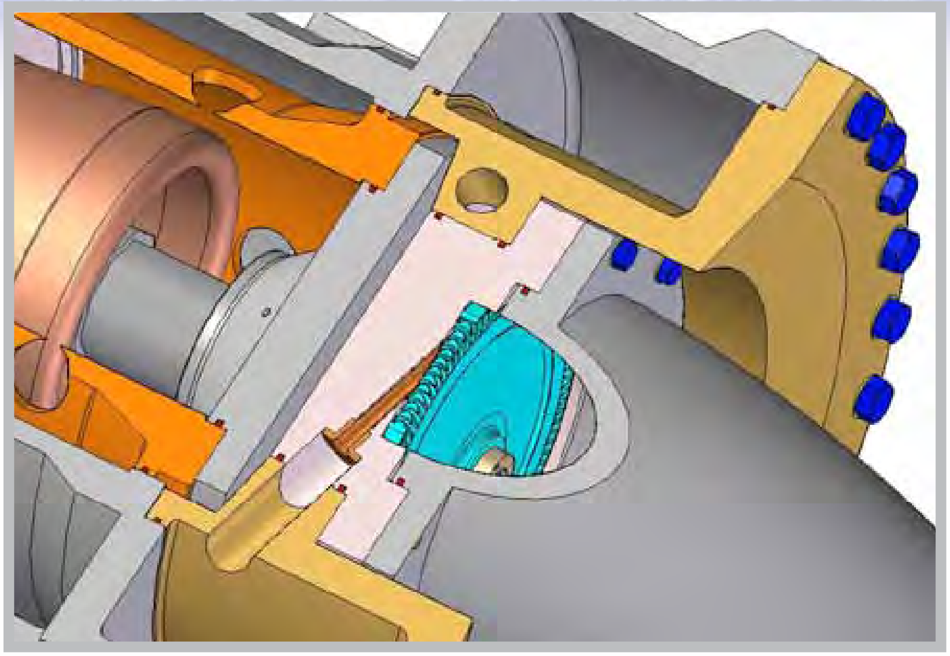
Waste expansion nitrogen plants are especially effective in remote industrial areas where it is uneconomical to deliver LIN by tanker truck and where LIN for back-up is required (see Figure 1). While GAN is being consumed in the facility (1), the small amount of LIN is stored for a multitude of uses (2) including back-up when the plant is off-line, to supplement GAN flow when there are peaks in demand, or when the plant is taken off-line to avoid peak power rates. Yet, there are instances when the storage tanks fill up because there are no uses for LIN. For this condition, Cosmodyne invented a simple design modification that eliminates LIN production and saves power, while continuing to produce GAN, without interrupting the overall operation. This patented technology works automatically and includes the following steps: sensing a full storage condition (3), on full storage, routing cryogenic liquid from the bottom of the nitrogen column to an external vaporizer (4), converting the liquid to gas (5), introducing the gas back to the column (6), and using the heat in the returning gas to remove excess refrigeration (7), thereby stabilizing the column at this new design point. The benefits of this design are two-fold: first, the unwanted LIN is converted to GAN and used in the facility without a pump and vaporizer as it would be coming from the storage tank. Converting the LIN to GAN allows the air compressor to be turned down, thus saving power (blue line on Figure 2). Secondly, this modification results in a higher GAN to air yield which allows the air compressor to be turned down even further and produce the same amount of GAN (red line on Figure 2).

Figure 3: Typical TGN Installation

Without this modification, a customer's only solution for a full storage condition would be to (a) vent LIN through a disposal vaporizer, (b) turn-down the air compressor to make less GAN and LIN while vaporizing and compressing LIN from storage, or (c) shut down the plant while vaporizing and compressing LIN from storage. All of these options result in a higher overall power consumption than the power consumption obtained using the modification.

For more information on this article, please reference US Patent No.: US 7,555,918 B1 or call Melania Charles at Cosmodyne LLC at 562-590-7995 or mcharles@cosmodyne.com.

Energent's Variable Phase Turbine Nozzle Flow



Two-Phase Nozzle Flow

Energent's Variable Phase Turbine[1, 2] (VPT) has a set of discrete nozzles upstream of the turbine rotor. The fluid is liquid at the inlet, flashes inside the nozzle, and is two-phase inside the rotor. A previous article[3] discussed calculating the trajectories of droplets inside the turbine rotor. This article will focus on the nozzle.

Energent has been using a 1-D code to design the nozzle. We are doing an experimental program to investigate the two phase flow inside the nozzle. The nozzle will be instrumented to measure pressure and temperature along the flow direction. The momentum flux will be measured indirectly as a contribution to thrust.

In the converging section of the nozzle, the pressure decreases. When it declines to the saturation pressure, vapor bubbles form. At this pressure, the liquid is the continuous phase, the vapor the dispersed phase. With a continued decrease in pressure, eventually the liquid is the dispersed phase as droplets. The development of the dispersed phase, from the formation of vapor bubbles to the transition to liquid droplets and the droplet breakup, is not an easy task to model in the Computational Fluid Dynamics (CFD).

A 3-D CFD study has been started with a commercial code from Numeca. The CFD code is being used under the assumptions of homogenous flow, with zero velocity slip, and the same pressure and temperature on both sides of the liquid-vapor interface. The complexities of the dispersed phase are being ignored.

Figures 1-2 compare the pressure and temperature calculated by the 1-D code and the 3-D CFD code. It is not surprising that they are not quite the same. For the CFD calculation, the two-phase flow was assumed to be homogeneous.

In addition, the flow field around a single droplet is being examined in detail using Direct Numerical Simulation (DNS). DNS solves the equations directly, without

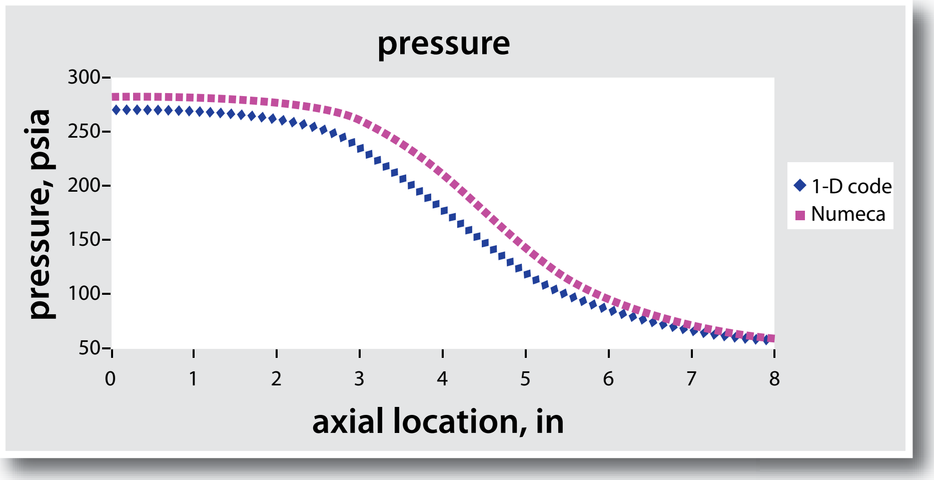


Figure 1. Pressure profile.

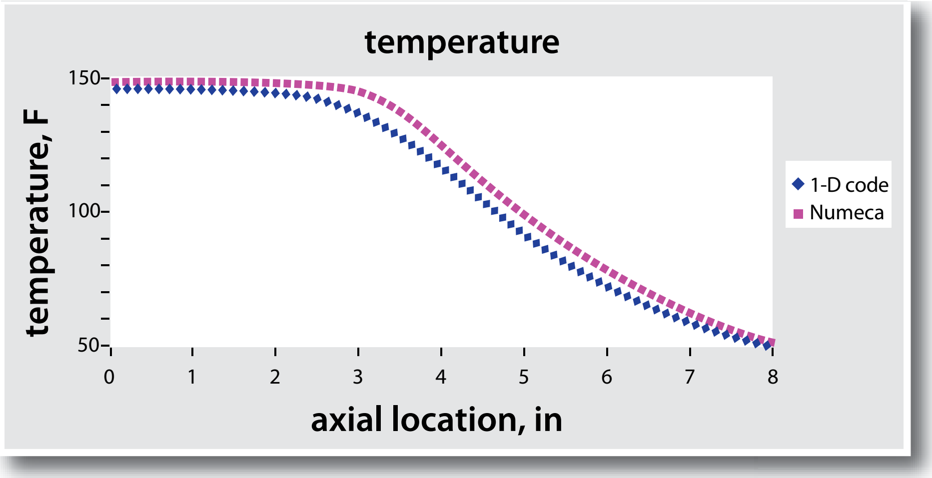


Figure 2. Temperature profile.

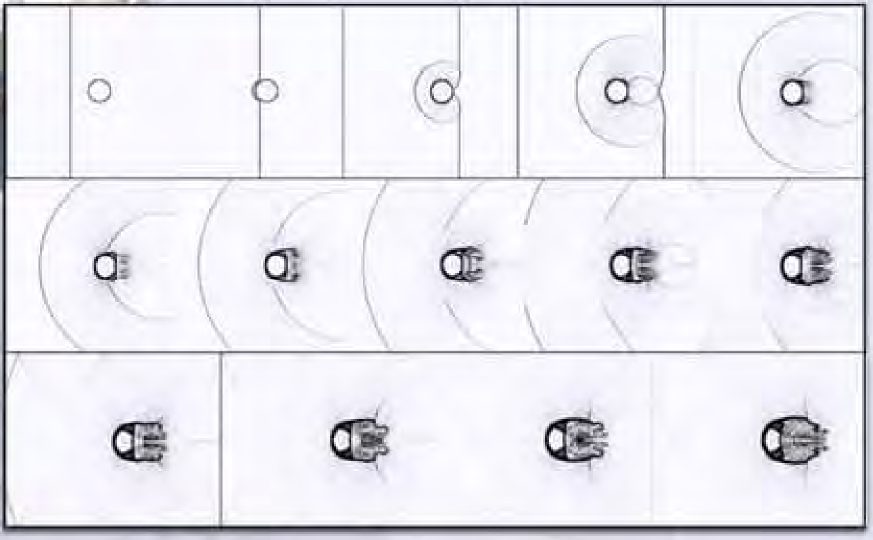


Figure 3. Schlieren images of a shock wave impinging on a liquid column.

needing to employ assumptions in order to model turbulence.

Initially a liquid column is being considered subject to an incoming shock. Figure 3 is a series of snapshots of a column breaking up, displayed as a Schlieren image of the density gradient.

Next the shock will be "smoothed" to better represent the pressure variation from the changing cross-section area inside the nozzle. The information gained from these simulations will be used to develop a reduced order model that can be incorporated into traditional CFD codes as well as the in-house 1-D code.

When the experiment is completed, a comparison will be made between the numerical calculations and the experimental results.

For a different nozzle, Figures 4-5 compare the pressure and temperature calculated by the 1-D code and the 3-D CFD code. For this nozzle the two codes give similar results. An objective of the two-phase nozzle program is to investigate why the numerical calculations do not always give comparable results.

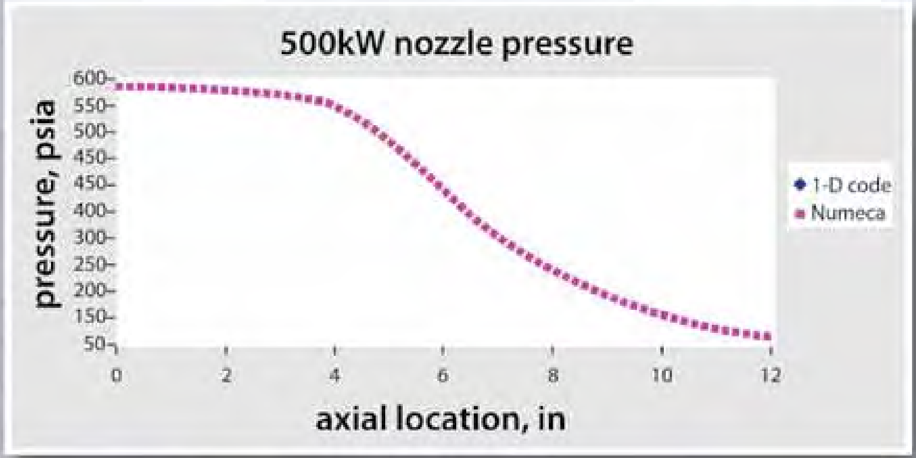


Figure 4. Pressure profile of a 500kW nozzle.

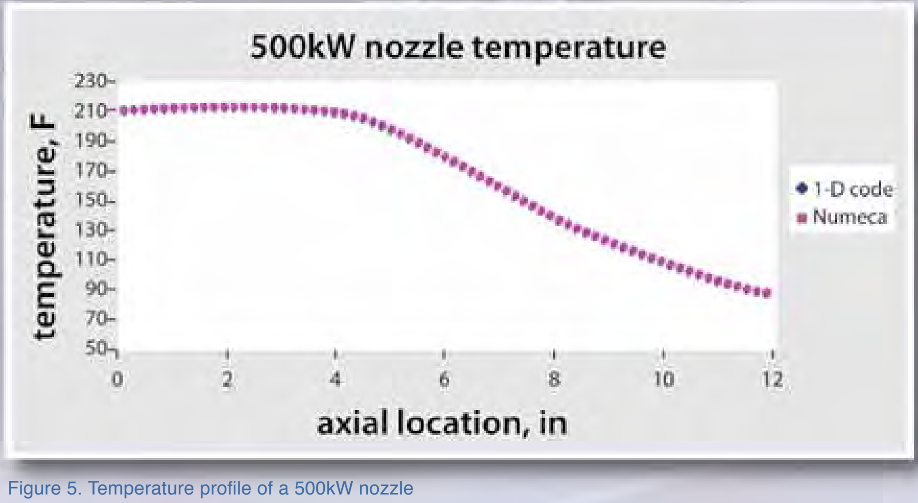


Figure 5. Temperature profile of a 500kW nozzle

For more information contact
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rfranz@energent.net.

1 Lance Hays, "The Energent Variable Phase Turbine expands liquids or supercritical fluids used in refrigeration," FrostByte, Summer 2008, pages 1, 4.

2 Lance Hays, "Cryogenic Liquid Expanders," FrostByte, Summer 2011, page 2.

3 Ron Franz, "Droplet Trajectories in a Turbine Rotor," FrostByte, Winter 2011, page 7.

Cryoquip Works To Create Drinking Water In Australia

Remineralization and Potabilization Systems

One of the main purposes of water treatment technology is to take untreated well or sea water and create clean drinking water for a thirsty world.

Desalination plants use a number of water treatment processes to create clean drinking water. The water treatment processes include:

- Clarification and filtration – separating suspended matter from liquids by forcing the liquid through a filter
- Ultrafiltration – a very fine filtration system that removes microscopic particles
- Sterilization – uses chlorine, chlorine dioxide, ozone and ultraviolet ray-based techniques to kill germs and bacteria
- Reverse osmosis – removes specific pollutants typically present in well water

The system involves a remineralization process which re-establishes the optimal level of salinity in a reverse osmosis permeate or in an evaporator distillate. Water to be remineralized is saturated with carbon dioxide and is made to flow through different filters. The reaction between carbon dioxide and calcium carbonate (which takes place naturally when water seeps through the layers of calcareous rock) causes the calcium or calcium+magnesium bicarbonate to become soluble.

The remineralization process is completed by injecting processed water with previously filtered seawater to provide the needed sodium chloride.

Potabilization

Before any water is released for consumption, the water must be treated using the processes described below. (The chemical dose and the filtration controls approach will vary depending on the site and the consequent approach to introducing the water to the supply system.)

Desalinated water from a two-pass reverse osmosis process will have very low concentrations of dissolved constituents. The water is aggressive and needs to be further treated before it is suitable for transfer into the supply network. Carbon dioxide and lime are added to increase the residual alkalinity and hardness of the water.

Dose rates are part of the conceptual design work and are aimed at producing water quality similar to the water supply already found in Melbourne. The Total Dissolved Solids (TDS), pH and calcium carbonate precipitation potential have all been considered.

It is anticipated that the final water quality will be in the range of 30 – 100 mg/L TDS, comparable to Melbourne's existing supply. The desalinated water is likely to be lower in dissolved sodium but higher in dissolved calcium than Melbourne's water.

Potabilization Process Description

- Water pH control and stabilization by dosing with lime and CO_2
- Levels of Calcium and alkalinity can be varied
- Targets require a compromise between protection of pipeline assets and keeping Calcium and alkalinity levels low, which could provide benefits to some industrial customers.

Cryoquip's Involvement in the Process

Cryoquip has supplied CO_2 vaporizers for desalination plants in the states of Western Australia, New South Wales, Queensland, Victoria and South Australia. Cryoquip CO_2 vaporizers have been installed at 8 desalination plants and many potable water supply systems.

CO_2 is used in the remineralization of the water after it has been desalinated, and is dosed in proportion with lime to ensure that the water chemistry is suitable for reticulation and personal consumption.

The desalination plant built for Southern Seawater Alliance (SSWA) was the second desalination plant built in Perth, the capital city of Western Australia. The plant has an annual capacity of 50 Gigaliters/year of water. The desalination plant produces water via reverse osmosis (RO). There are two RO trains, each with 80 Megaliters/day capacity. The CO_2 is injected into a side stream of the desalinated water, and dissolved in this stream through sintered filter dissolvers.

The normal CO_2 system flow rate for the Perth desalination plant was 70 to 170 kg/hr, with a maximum of 340 kg/hr. Other CO_2 systems for desalination plants are sized in excess of 700 kg/hr. We have just received another inquiry from Perth to duplicate the CO_2 system to double the plant's capacity

Cryoquip supplied all the bulk storage vessels, pipe work, vaporizers, dosing system and dissolvers for the Melbourne project, where it was shipped as a package to the site, and assembled by Cryoquip employees. The complete system was installed in under a week, ahead of schedule and within budget.

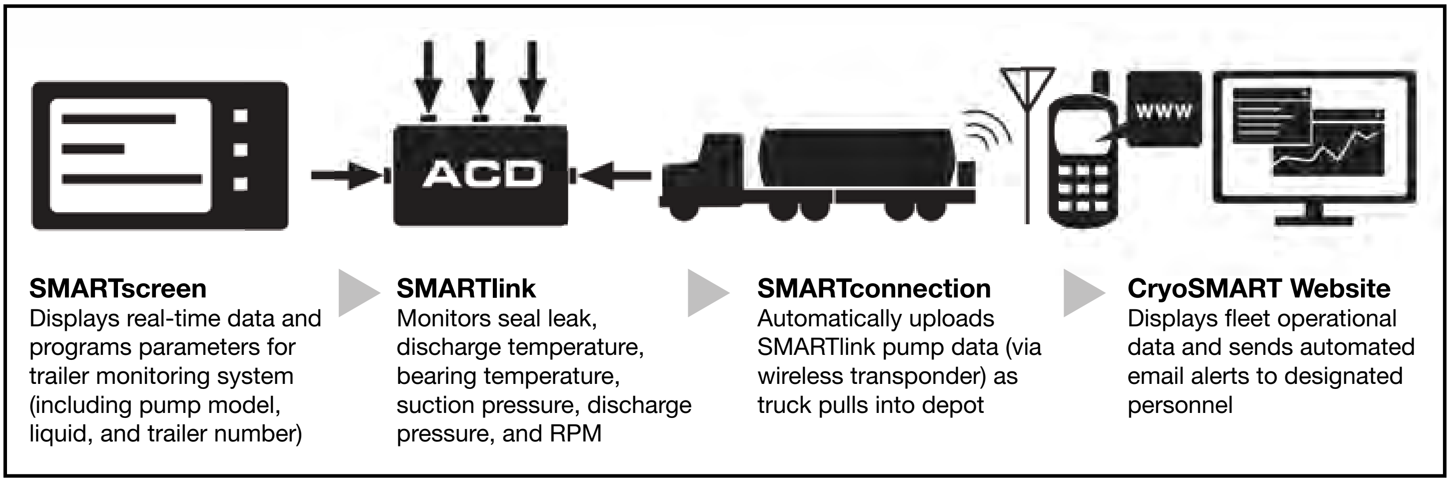
CO_2 storage vessels

A New Generation of Cryogenic Intelligence

ACD's CryoSMART System introduces a technology engineered to monitor trailer pump operation and minimize customer downtime by alerting the operator of potential problems. System Monitoring And Remote Tracking (SMART) are integral features to the CryoSMART System's design, which consists of the SMARTscreen, SMARTlink, SMARTconnection, and CryoSMART Website (see Figure 1).

Protecting our customers' interests was a goal set by ACD when it first began the development of a product capable of detecting and predicting future failures in cryogenic liquid transfer. The industrial gas transportation business relies heavily on the performance of cryogenic trailer transfer pumps in day to day operations. Failure to successfully transfer liquid to or from delivery vehicles bears considerable economic consequences.

Conjointly, the system monitors parameters for trailer pumps powered by ACD Lectran, hydraulic, or jackshaft (Pony) type systems to ensure operation within a specified range of predetermined parameters. To enable remote fleet management, the system provides automated email alerts notifying either ACD's service network or customer fleet locations of pending failures.



SMARTscreen
Displays real-time data and programs parameters for trailer monitoring system (including pump model, liquid, and trailer number)

SMARTlink
Monitors seal leak, discharge temperature, bearing temperature, suction pressure, discharge pressure, and RPM

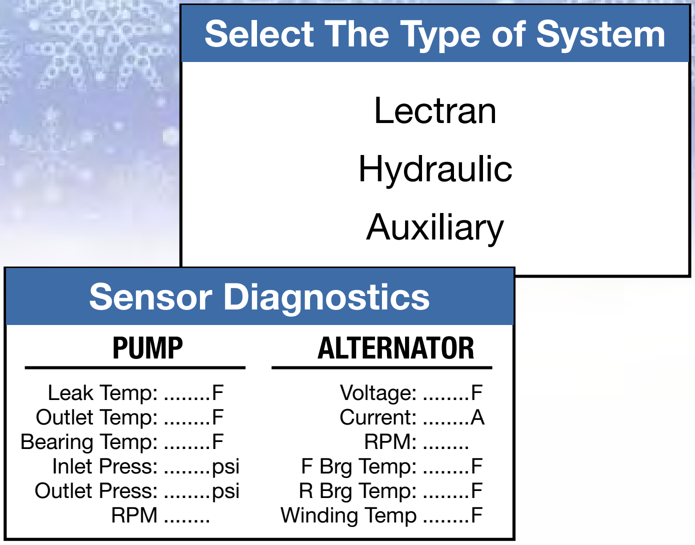
SMARTconnection
Automatically uploads SMARTlink pump data (via wireless transponder) as truck pulls into depot

CryoSMART Website
Displays fleet operational data and sends automated email alerts to designated personnel

Figure 1. CryoSMART System Process.

SMARTscreen

Remote tracking capabilities are first initiated through the mobile interface terminal (SMARTscreen), which programs equipment parameters such as the pump model, serial number, product, type of power system, and customer trailer number (see Figure 2). Designed as a handheld touch screen, the SMARTscreen is powered by the tractor/trailer SMARTlink and can also be used to upgrade existing SMARTlink firmware or display real-time data for training and troubleshooting.



Select The Type of System

Lectran
Hydraulic
Auxiliary

Sensor Diagnostics

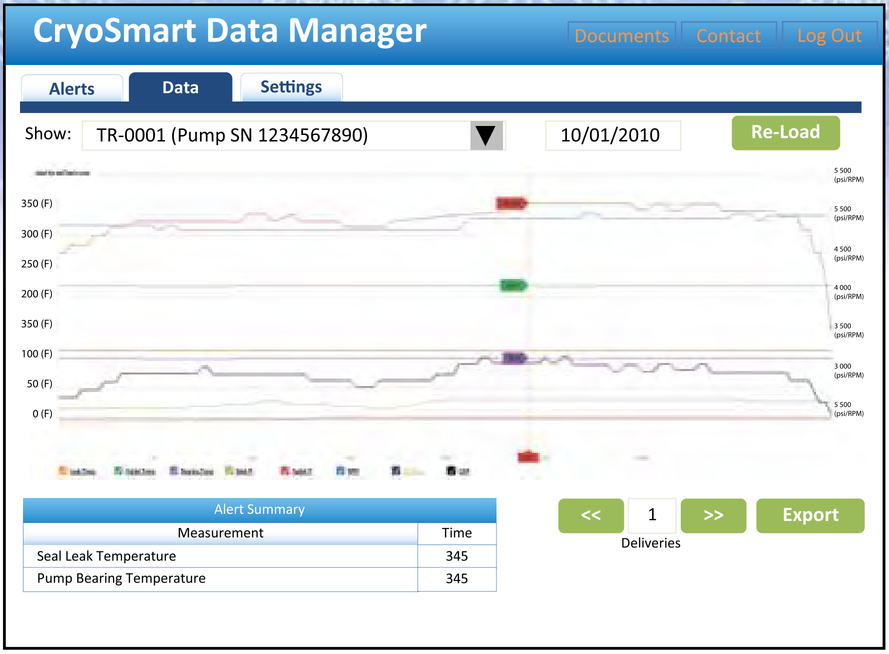
PUMP	ALTERNATOR
Leak Temp: ....F	Voltage: ....F
Outlet Temp: ....F	Current: ....A
Bearing Temp: ....F	RPM: ....
Inlet Press: ....psi	F Brg Temp: ....F
Outlet Press: ....psi	R Brg Temp: ....F
RPM	Winding Temp ....F

Figure 2. SMARTscreen System Selection and Sensor Diagnostics.

SMARTlink

The CryoSMART System's main control unit (SMARTlink) is a micro processor based intelligent system stationed on the trailer, capable of receiving, storing, and ultimately transmitting pump information to the website. The SMARTlink is powered by the trailer's electrical system (8 to 30 VDC) and accepts liquid transfer information provided by various sensors located on components critical to the delivery process.

Monitored performance includes: pump speed, suction and discharge pressure, mechanical seal area, discharge, and bearing temperatures (via 4-20 mA pressure sensors and RTDs). For Lectran systems, the alternator also is monitored to ensure the voltage, currents, speed and temperatures all operate within given ranges. Information stored in the SMARTlink control module is then automatically transmitted from a transponder to a computer terminal (SMARTconnection) located at the depot when the transport vehicle returns, which can be easily reviewed online by the plant manager (see Figure 3).



Show: TR-0001 (Pump SN 1234567890) 10/01/2010

Alert Summary	
Measurement	Time
Seal Leak Temperature	345
Pump Bearing Temperature	345

1 Deliveries

Figure 3. SMARTlink Data Transmitted to Website.

Data recording starts:

- Pump temperature ≤ 100°F
- Pump RPM ≥ 100 RPM
- Pump discharge pressure ≥ 100 PSI

Data recording stops:

- Pump temperature ≥ -100°F
- Pump RPM ≤ 100 RPM
- Pump discharge pressure ≤ 100 PSI

SMARTconnection

Consisting of a transponder and industrial PC, the SMARTconnection transmits the information stored in the SMARTlink control module to the CryoSMART website. The wireless transponder (installed at the depot) receives a signal from the SMARTlink when the trailer arrives and then transmits the data to a compact PC installed onsite. Using embedded firmware, the PC automatically uploads the SMARTlink data to the CryoSMART website for secured customer access.

CryoSMART Website

In order to provide accessible fleet management, the CryoSMART website sorts and manages all recorded trailer data in a user-friendly online database (see Figure 4). With CryoSMART Mobile, customers are able to access a mobile version of the website and receive system status notifications from any worldwide location.

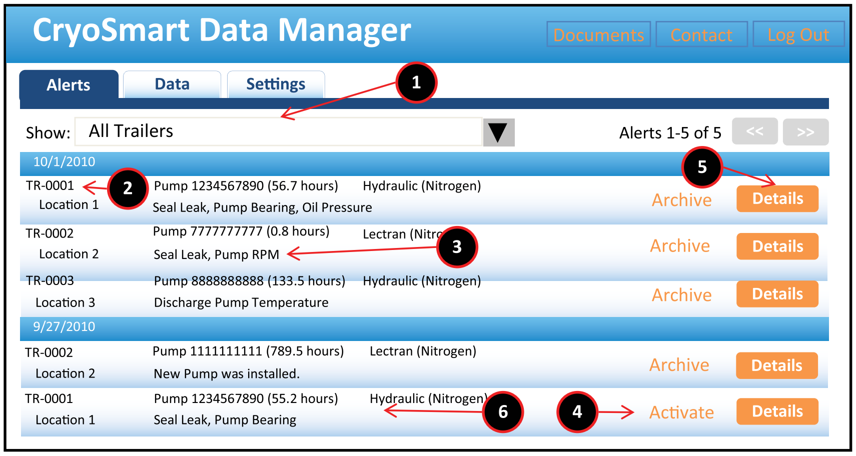
Secured log-in and password protection allow customers to safely view and manage fleet data according to established administrator/user level. To enable remote fleet management, the CryoSMART website provides automated email alerts upon detection of abnormal operating conditions, including automatically generated graphs and reports with Microsoft Excel export capabilities, PDF manuals, technical support contact information, and advanced sorting preferences by location/region, trailer number, date range, or alert type.

The Future of Cryogenic Liquid Transfer

ACD's CryoSMART System introduces the advanced technology capable of predicting and preventing liquid transfer failures. Customers can now receive notification when operation exceeds given parameters, allowing them to schedule exchanges or repairs of the pump and/or power system. Based on usage and performance trends, fleet operators can anticipate system behavior and initiate preventative pump maintenance.

This new generation of cryogenic intelligence heralds a future in which customer downtime will be viewed as an anomaly—a future where maximum efficiency and full system visibility will become the paradigm for the industrial gas transportation business.

For more information, please contact Melissa Foltman, + 1 949.261.7533. ext 386, or mfoltman@acdllc.com.



Show: All Trailers

Alerts 1-5 of 5

10/1/2010

TR-0001 Location 1	Pump 1234567890 (56.7 hours) Seal Leak, Pump Bearing, Oil Pressure	Hydraulic (Nitrogen)	Archive	Details
TR-0002 Location 2	Pump 7777777777 (0.8 hours) Seal Leak, Pump RPM	Lectran (Nitro	Archive	Details
TR-0003 Location 3	Pump 8888888888 (133.5 hours) Discharge Pump Temperature	Hydraulic (Nitrogen)	Archive	Details

9/27/2010

TR-0002 Location 2	Pump 1111111111 (789.5 hours) New Pump was installed.	Lectran (Nitrogen)	Archive	Details
TR-0001 Location 1	Pump 1234567890 (55.2 hours) Seal Leak, Pump Bearing	Hydraulic (Nitrogen)	Activate	Details

1. Sorting options by trailer number or "All trailers"
2. User established trailer number or MFG serial number
3. Identifies measurement that caused alert
4. Archive feature to remove alert from Active list
5. Shows details of pump operation
6. Inactive alerts

Figure 4. CryoSMART Website Alert Management Database.

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A NEWSLETTER FROM CRYOGENIC INDUSTRIES

CRYOGENIC INDUSTRIES

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Cryogenic Industries
Companies

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