CRYOGENIC INDUSTRIES

FROSTBYTE

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The Energent Variable Phase Turbine expands liquids or supercritical fluids used in refrigeration

Expansion of a liquid or supercritical fluid into the two-phase region is used in refrigeration processes for cooling or to produce liquid cryogenic products. The component which is commonly applied for this service is a pressure letdown valve, or Joule-Thomson (J-T) valve. While simple, the J-T valve results in a frictional dissipation of the available pressure energy, producing heating and less liquid product than would result from an isentropic expansion.

This result is illustrated on the temperature-entropy diagram of Figure 1. An isenthalpic, J-T, expansion from liquid, state point 1, into the two-phase region, state point 2, is shown. The liquid fraction is a/c. An isentropic expansion from state point 1 to state point 3 would result in a liquid fraction of b/c where b>a. For many processes the vapor generated by the flashing must be recompressed. By the reduction of the vapor fraction produced, from 1-(a/c) to 1-(b/c), the two-phase isentropic expansion reduces the compressor size and power.

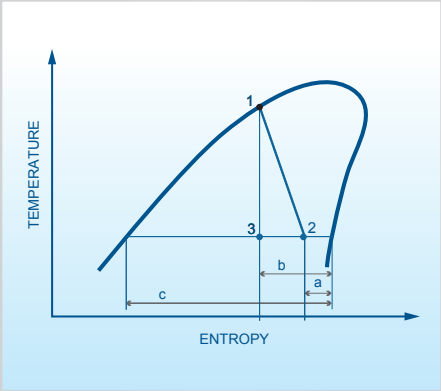
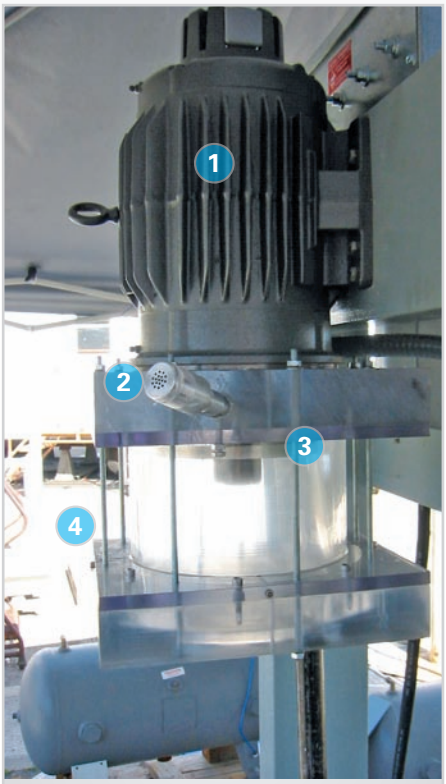


Figure 1: Comparison of Isentropic and Isenthalpic Two-Phase Expansions



1 Generator
2 Nozzle
3 Turbine Wheel
4 Separator

Figure 2: LN_2 Variable Phase Turbine Test Setup

Energent has developed a turbine which efficiently expands liquids or supercritical fluids into the two-phase region. This turbine, the Variable Phase Turbine (VPT) generates shaft power from the available pressure energy. The shaft power is removed from the process, increasing the cooling relative to a J-T valve and generating useful power as a byproduct. Hermetic units having process fluid cooled bearings and generator are being designed.

Figure 2 shows a small, 1.5 kW, VPT which was operated with liquid nitrogen. The inlet LN2 stream was liquid at -177 degC. This stream was flashed in the VPT to atmospheric pressure. The small size required only a single two-phase nozzle, resulting in partial admission losses. However, the measured efficiency was still 56%, with a rotor efficiency of 77%. The vapor production in the expansion was reduced by 7% compared to expansion in a J-T valve.

Figure 3 shows a comparison of the measured power to that predicted using two-phase nozzle and turbine design codes. The measured power agrees well with that predicted over a range of turbine speed.

Larger units, >100 kW, will have a turbine efficiency of greater than 80%. For cryogenic process applications, increases of 10-15% in the output of liquid product are possible for fixed compressor and heat exchanger capacities. Applications include LNG and ethylene production and propane, ammonia, CO_2 and other industrial refrigeration.

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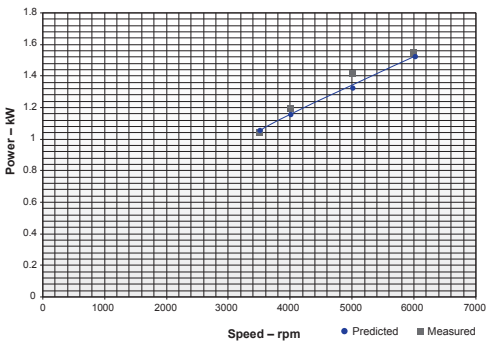
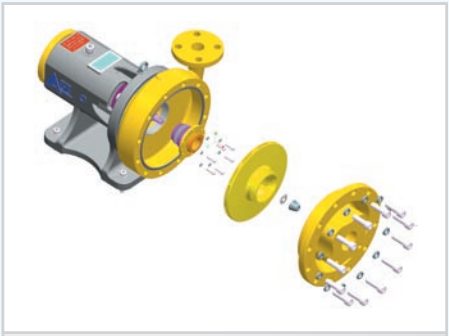


Figure 3: Comparison of Measured and Predicted Power in LN_2 Two-Phase Axial Turbine

The ACD TOP Series outperforms its competitors

ACD's new TOP Series (Trailer Oil-lubricated Pump), with its robust design and many features, has proven itself to operators in the trailer off-loading and transfer pump marketplace. The TOP exceeds industry standards for mechanically sealing and overall product performance. In direct comparison to other trailer off-loading pumps, the TOP 260 outperforms all competitors for sealing life and pressure/output flows. As predicted, the TOP Series stands to revolutionize how centrifugal pumps are designed and operated for transfer applications.

A sealed bearing housing requires no maintenance or periodic filling of oil between recommended service intervals (up to 6,000 hours or three (3) cartridge seal exchanges). Oxygen-compatible oil is used as the standard lubricant and the bearing housing is designed in compliance with CGA G-4.7 and EIGA/IGC 11/82 guidelines for centrifugal oxygen pumps.



If the configuration of the trailer's plumbing allows, the cartridge seal can be replaced in the field… without removing the pump!

Simplifying mechanical seal repairs/exchanges is solved with the TOP Series. In addition to ease of replacement, the cartridge seal ensures proper installation and minimizes human error. The seal features the latest composite face material and comes preset for guaranteed performance.

The flow and pressure capacities are not pump-design limited, rather power-input limited from the on-board power (pony engine or PTO) of the trailers. With designed maximum power capacity of 134 hp (100 Kw), the TOP 260 can reach differential pressures up to 1,475 ft (450m) and flows up to 290 gpm (1,100 lpm). For laser-fill applications where higher pressures are needed, the TOP 180-2s is available with maximum flows and pressures up to 225 gpm (850 lpm) and 2,200 ft (670 m) differential head, respectively.

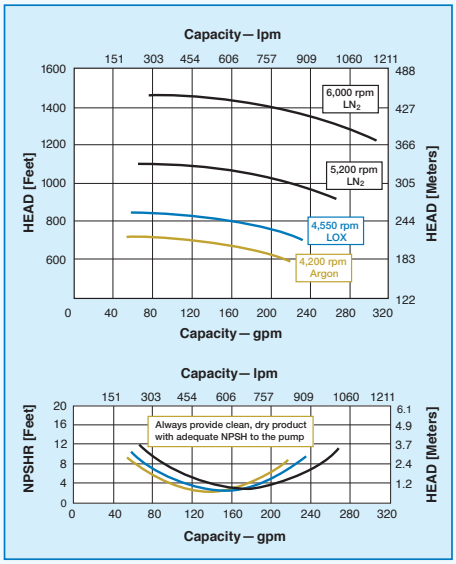
The TOP 260 can be interchanged with the existing trailer pump installation. The bolt-hole pattern and mating flange connections are the same dimensions and height locations.

The TOP Series is user-friendly and provides real-world operational benefits, i.e., cost savings. The extended life of the cartridge seal and the sealed bearing housing, which does not need serviced for up to 6,000 hours, means two things: 1) lower maintenance costs, and 2) more reliable operation.

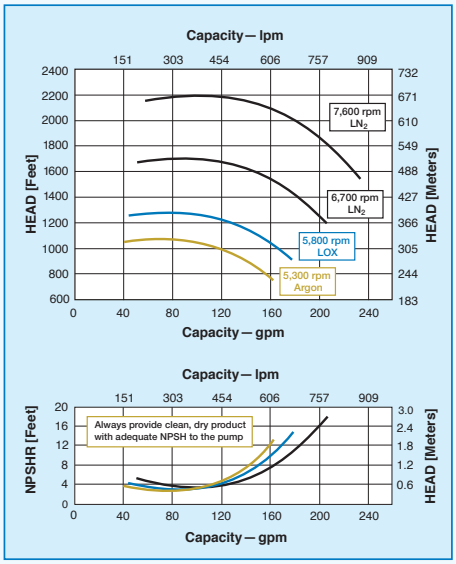
Design Features:

- Oil-Lubricated Bearing Housing
  - O_2 Compatible
- Full Mechanical Cartridge Seal
- Structural Design (5 times stronger)
  - One piece casting for Bearing Housing and Intermediate
- New Shaft and Impeller Attachment
- Cylindrical Roller Bearings
- Improved Volute Design with DU Bushing
- **Interchangeable** with existing trailer pumps

TOP 260J or HD



TOP 180 – 2s J or HD



The versatility of the TOP Series reaches into other markets/applications: oil well service. For natural gas and oil production, the TOP Series is used as a 'boost' pump to feed ACD's larger SLS series pumps. The TOP 215H (hydraulically driven) is used to accommodate the inlet flow and pressure requirements of 350 gpm (1,330 lpm) at 150 psi (10 bar) of the 5-SLS.

For more information contact Denis DePierro at ACD, +1.949.261.7533, ddepierro@acdcom.com. Or a worldwide ACD authorized sales and service center at www.acdcom.com.

The severe duty requirements of natural gas/oil production illustrate the rugged design and features of the TOP Series… which benefit industrial gas applications for trailer off-loading and/or transfer – design features and performance exceed industry standards…a proven performer.

Shipped to the Pacific Rim late last year, ACD's largest set of turboexpanders will be commissioned in 2009. Both the TC-12000 and TC-9000 deliver almost 3300 hp of refrigeration for the plant process. Both were cryogenically tested before shipping, and proved to exceed the guaranteed customer requirements. These units were designed to meet stringent customer and end user specifications including a full API 614 lubrication system.

ACD turboexpanders are custom designed to suit your plants requirements. Sizes range from 765 acmh (450 acfm) and 335 kw (450 hp) to 27,200 acmh (16,000 acfm) and 6000 kw (8000 hp). The ACD turboexpander cryogenic test facility ensures performance at full operating temperature and up to full load or full speed. Cryogenic testing uses nitrogen as the working fluid with a modified PTC-10 test arrangement.

For more information contact Tom Gerhard at ACD, +1.949.261.7533 or tgerhard@acdcom.com.

Cryoquip-Australia supplies and installs a road tanker filling system for a new nitrogen liquefier

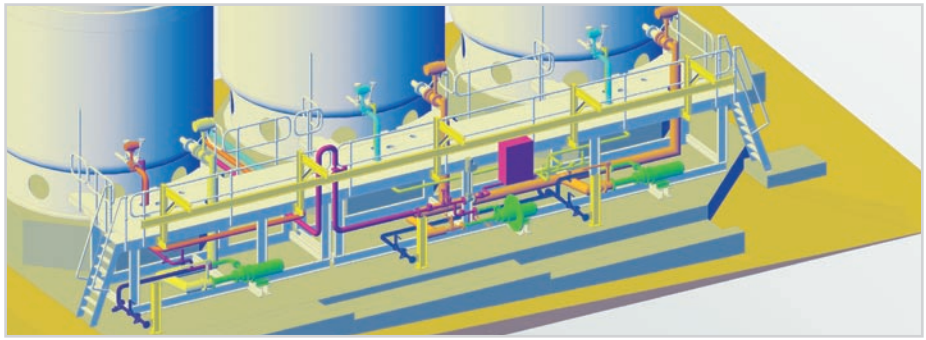
Cryoquip-Australia recently finished a major site installation at Coregas's nitrogen liquefaction facility in Port Kembla, NSW, Australia. The project involved the installation of over 300 m of vacuum insulated pipe work and three major pumping and vessel skids for the road tanker filling system.

The customer required a supplier who could package the pumps and valves in an ergonomic pumping system, allowed operators to easily access valves and instruments on their vessels, and access and maintain pumps while ensuring efficient operation of the system.

Cryoquip was supplied the process and instrument diagrams (P&ID's) for the liquid oxygen, nitrogen and argon system, and from this, designed and specified the valves and pipe work, and produced a 3-D CAD model of the system. The system was approved by the customer and Cryoquip-Australia built the packaged skids in their manufacturing facility in Melbourne, and installed the skids and pipe work on-site. The installation was completed on time and within the budget constraints of the project.

Other systems have been fabricated and ready for on-site installation for BOC in Australia, for their Ausmelt project in remote South Australia, and for Kuwait Industrial Gases.

For more information contact Ralph Day at Cryoquip, +61.3.9791.7888 or rday@cryoquip.com.



The Energent Variable Phase Turbine

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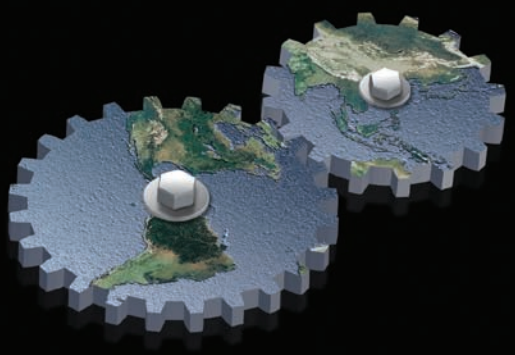
For waste heat recovery use of a Triangle Cycle with a VPT has been shown to result in a 20-40% improvement in power output compared to an organic Rankine cycle. Figure 4 is a photograph of a Triangle Cycle pilot plant for waste heat recovery. The pilot plant operates with high temperature refrigerants such as R245fa to demonstrate cycle efficiency and to provide a test bed for turbine designs. Applications include waste heat recovery from industrial plants, engines and gas turbines and for geothermal power generation.

For more information contact Lance Hays at Energent, +1.949.261.7533 or lhays@energent.net.

1 Variable Phase Turbine

Figure 4: Triangle Cycle Pilot Plant



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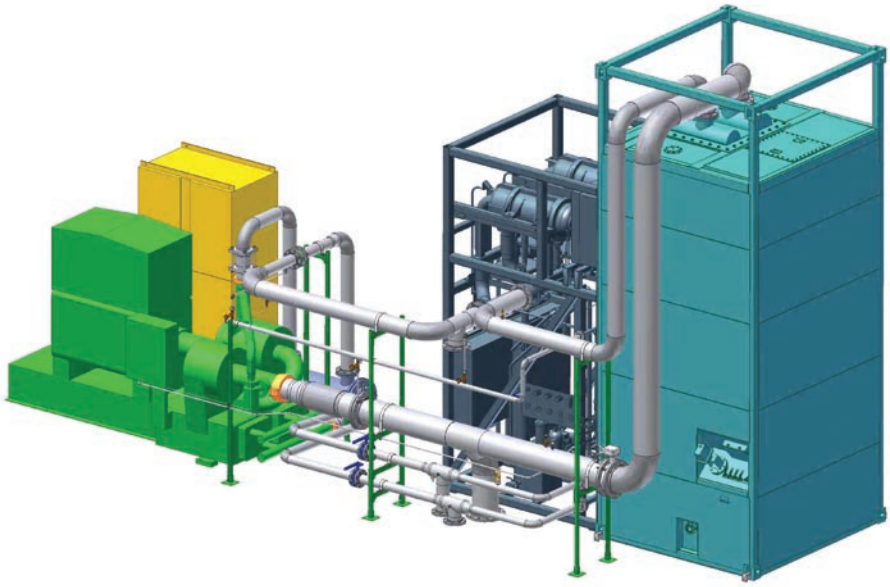
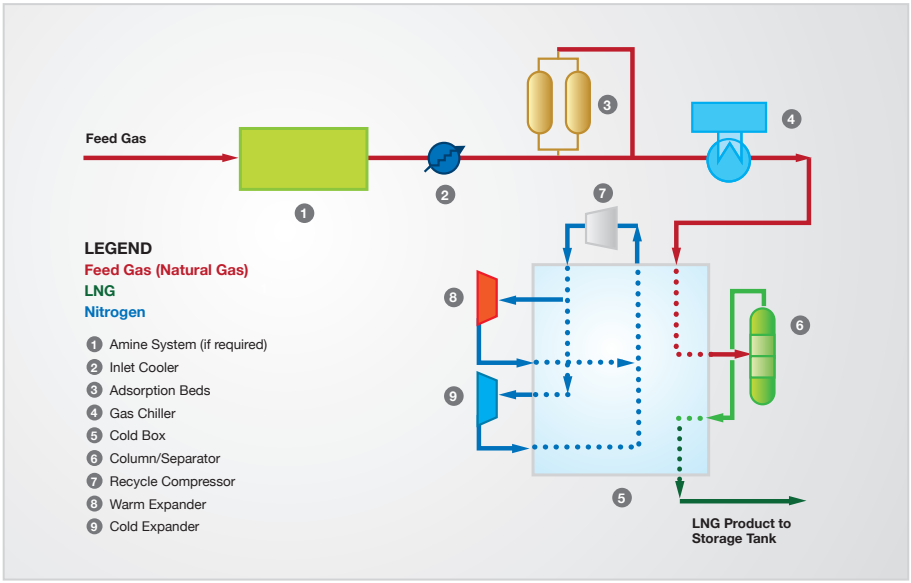
Cosmodyne delivers LNG liquefiers to large-scale production plant in California

To meet the ever-increasing demand for alternative fuels, Clean Energy Fuels Corp. has begun construction on California's first large-scale LNG (liquefied natural gas) production plant near Boron, approximately 75 miles northeast of Los Angeles. Cosmodyne's 160,000 gallons per day nitrogen cycle liquefier is the heart of the plant. Cosmodyne was selected for its 50 years of cryogenic engineering experience, utilization of "green" refrigerant, and simple modular plant design that allows for quick and easy installation. The Cosmodyne liquefier was delivered on time in March 2008 and is currently being commissioned. The Boron plant is scheduled to begin commercial LNG shipments in the second half of 2008.



Cosmodyne provided two liquefier systems, each consisting of a cold box rated for 80,000 gallons per day, a nitrogen compressor, dual booster loaded ACD turboexpanders and a heat exchanger. In addition, a pipeline gas adsorption system feeding both liquefier systems was provided. Cosmodyne utilizes environmentally-friendly nitrogen as the refrigerant to liquefy the pipeline gas to LNG. The use of nitrogen eliminates the requirement for hazardous hydrocarbon refrigerant storage associated with mixed refrigerant cycles.

Working together with Clean Energy from the concept stage, Cosmodyne's team was able to provide numerous performance iterations, detailed design support and recommendation in plant engineering. For example, due to the high feedgas pressure, the cold box piping and fractionating column were fabricated in stainless steel instead aluminum. However, the cold box design with this added weight required close monitoring to meet the allowable road transportation limits. Similarly, to reduce cost and increase safety, the liquefier layout was arranged so that major system components such as the recycle compressor were able to be designed for non-hazardous area. Thus, limiting only those items in contact with natural gas to comply with the more costly NFPA-59 requirements.



At this new plant, Clean Energy will liquefy pipeline gas for shipment to customers by tanker trailers. The LNG will be used by vehicle fleets throughout California and the southwestern United States. The facility can be expanded to a production capacity of 240,000 gallons per day. The plant will also have LNG storage capacity of 1.5 million gallons.

Clean Energy's Boron plant is the first commercial LNG plant in California to serve the growing demand from heavy-duty natural gas vehicle fleets such as those at the Los Angeles Ports. The Boron plant is also a major step towards fueling thousands of additional buses and trucks with natural gas, one of the cleanest burning fuels available. Natural gas vehicles emit significantly less greenhouse gases and pollution than vehicles fueled by diesel or gasoline.

For more information contact George Pappagelis or Joseph Pak at Cosmodyne, +1.562.795.5990, info@cosmodyne.com.

CRYOGENIC INDUSTRIES

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Wittemann designs a CO_2 wash system for landfill gas cleanup

The Wittemann Company has designed, fabricated and supplied a 300 scfm CO_2 wash unit, operated by the Solid Waste Authority of Central Ohio (SWACO) in Columbus, Ohio. When fully operational, the facility will generate 250 kW of renewable electricity for use in the landfill gas cleanup process, and one thousand gasoline gallon equivalent of compressed natural gas (CNG) daily for use by SWACO and other local vehicles. This will significantly reduce SWACO's energy consumption, emissions, and fleet operating costs. Wittemann supplied the unit to FirmGreen Energy Inc., (FirmGreen) a privately held energy company participating in the global green energy business. FirmGreen is a licensee of the patented Acrion CO_2 Wash System.

FirmGreen's landfill gas-to-energy model involves a multi-faceted approach to energy development. As opposed to conventional gas-to-electric or gas-to-pipeline projects, FirmGreen developed a flexible business model that facilitates a wide variety of energy products from landfill gas, including CNG, ethanol, and methanol, in addition to conventional electric or pipeline gas. Wittemann's involvement includes the detailed engineering for the Acrion Wash System, plus the membrane separation, purification and additional subsystems required to produce the desired energy feed gas stream.

For more information contact Bill Geiger at Wittemann, +1.386.445.4200, bgeiger@wittemann.com.