



FROSTBYTE

A NEWSLETTER FROM CRYOGENIC INDUSTRIES WINTER 2011

Cosmodyne's Poplar 1500 Commissioned In El Salvador

In 2008, INFRA de El Salvador purchased Cosmodyne's POPLAR 1500 Air Separation Plant to meet the growing electronic industry demand for high purity gaseous nitrogen as well as to supply industrial gases to local markets. The plant, in production since June, 2010, is located in San Bartolo, El Salvador which is adjacent to the Free Zone (tax free area).

El Salvador is the most densely populated country in Central America with a population of approximately 6 million. The country is located between Guatemala and Honduras and has the third largest economy in the region.

Cosmodyne's POPLAR 1500 plant is a perfect fit for INFRA de El Salvador's needs with the right mix of production capability, efficiency and cost. INFRA de El Salvador needed a plant that delivered high purity nitrogen gas with less than 2 ppm of O_2 as well as liquid nitrogen, oxygen, and argon products. The high purity nitrogen being delivered "over the fence" by pipeline to various customers was a very important requirement to further enhance the economics of the plant. With a standard total capacity of 52 tons per day of liquid oxygen, nitrogen, and argon and 55 tons per day of high purity gaseous nitrogen, the POPLAR 1500 is able to meet all INFRA de El Salvador's production requirements. Furthermore, the POPLAR 1500 is much more efficient compared to other larger plants, which made it the best choice.

The POPLAR 1500 plant also addressed INFRA de El Salvador's transportation concerns. San Bartolo is about 100 miles away from the ports of El Salvador, and transportation of large equipment to San Bartolo is difficult and expensive because of narrow roads and many bridge crossings. The modular design of the plant made transportation easy and minimized freight costs. The entire plant, except for the coldbox, was packed in ten standard ISO containers and was easily transported to San Bartolo from the port in about 24 hours.

INFRA de El Salvador, formerly called Messer of El Salvador, was formed in early 2004 as an alliance between Grupo Mexico



OXGASA, INFRA, and Air Products. These companies have extensive experience in production and distribution of industrial gases. OXGASA is renowned for its leadership in the marketing of equipment and industrial and medical accessories since 1959. INFRA Group is a leading producer of industrial and medical gases, as well as the marketing of welding equipment in Mexico. Air Products is one of the largest industrial gas companies in the world.

*For more information contact Joseph Pak at Cosmodyne,
+ 1 562 795 5990 or jpak@cosmodyne.com.*



The Third Dimension of Engineering

Over the course of the last two decades, advancements in parametric solid modeling programs have revolutionized the field of mechanical engineering. When **ACD** began using Pro/ENGINEER (ProE) about seventeen years ago, the state-of-the-art program was used to model the complex surfaces of the turbine wheels and perform a Finite Element Analysis (FEA) to determine the natural frequencies of the blades. Early versions of the ProE program also enabled **ACD** to model parts and perform stress analysis on some complex structures.

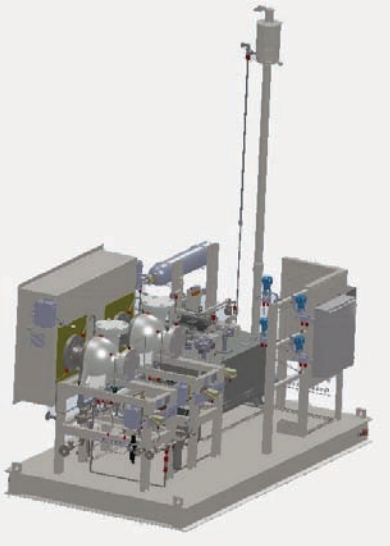


Figure 1

ACD's engineering group has standardized its engineering efforts with the use of SolidWorks, another advanced 3-D Computer-Aided Design (CAD) software program. SolidWorks allows **ACD** engineers to produce P&ID and electrical diagrams, schematics, manufacturing and assembly drawings, centrifugal and reciprocating pump and turboexpander system assemblies. Engineers can now perform stress, modal, heat transfer, and flow analysis to ensure product performance using the program results. Additional software features allow the creation of product bulletins and IOM manuals, as well as the ability to utilize Computer-Aided Manufacturing (CAM) via its fully-integrated SolidCAM program, which can be used to create the CNC code for both lathes and 5-axis milling machines.

With the ability to quickly produce customer submittal drawings (such as P&IDs and Electrical and Interface Control Drawings) in the early stages of each project, solid modeling software has continued to revolutionize the mechanical engineering process. BOM's can now be directly imported into the MRP system and ICD drawings and manufacturing programming can be created directly from models, significantly improving accuracy. Additionally, design time for new pump applications is significantly reduced as most of **ACD**'s pump product line is fully modeled in 3-D.

With the continuous evolution of 3-D solid modeling software, engineers are now able to use these programs for complete product lifecycle applications. **ACD** employs 3-D modeling tools from product conception through design to the creation of IOM manuals. Software development has made rendering the necessary deliverables for each of **ACD**'s product lines possible within one integrated package (as illustrated in Figures 1, 2, and 3).

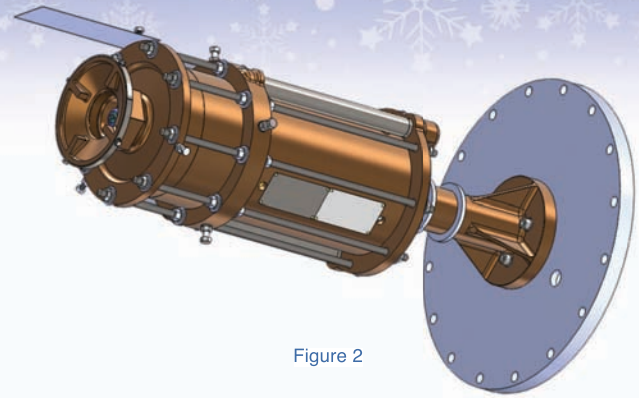


Figure 2

The trend of CAD-driven engineering has grown worldwide. SolidWorks has been used extensively in India by Cryogenic Design Services (CDS), a company providing support in creating models and assemblies of **ACD** pumps and turboexpanders. SolidWorks is fully integrated with the corporate Product Lifecycle Management (PLM) package, providing full control and management of all the electronic data produced by the engineering groups and allowing the sharing of information among group companies.

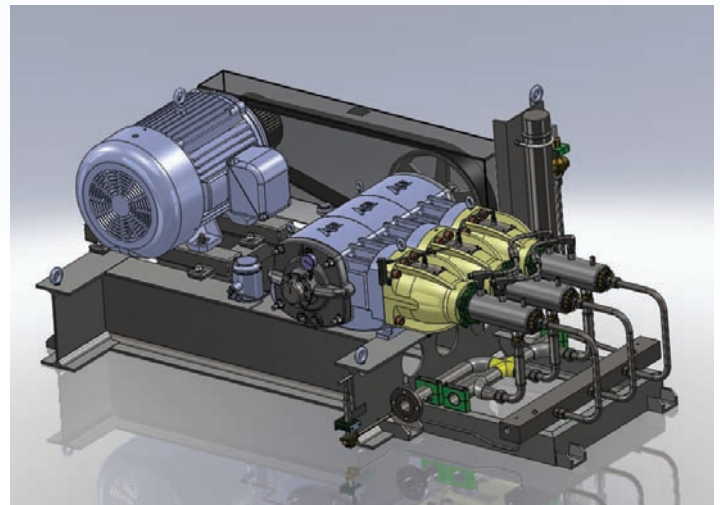


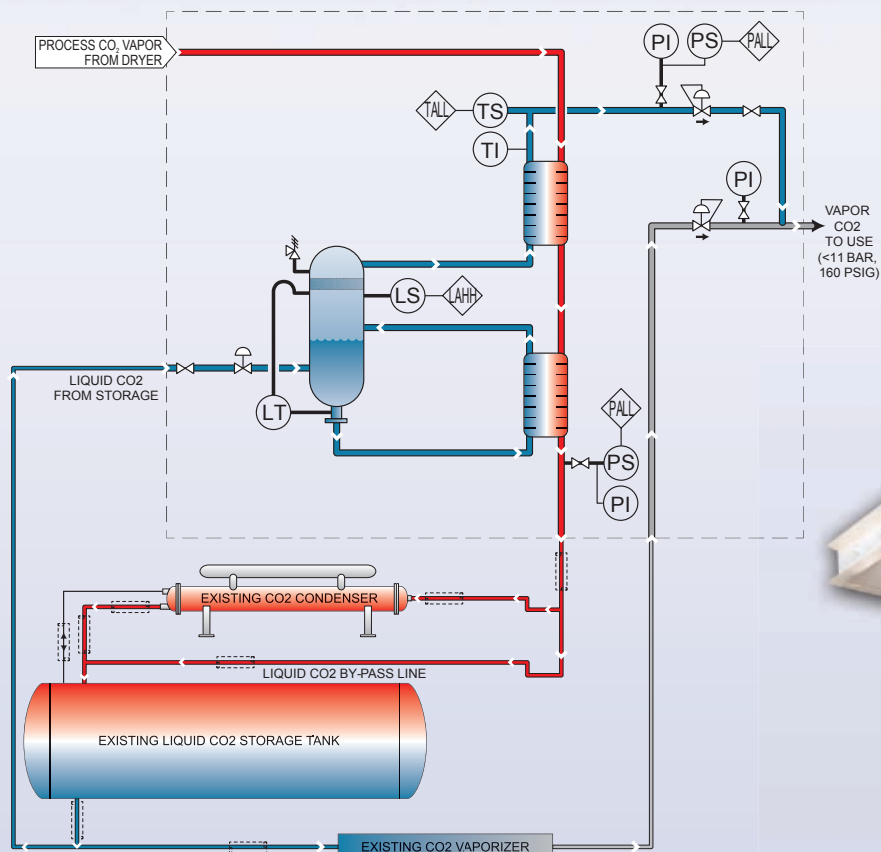
Figure 3

As parametric solid modeling programs continue to advance, engineering and manufacturing capabilities will evolve. **ACD** continues to utilize the latest advancements in software and manufacturing technology in an ongoing effort to provide our customers with the latest efficiency and reliability-enhancing options. Future issues of Frostbyte will have articles on the process and advantages of stress analysis, modal analysis, computational fluid dynamics, and computer-aided manufacturing.

For more information contact Craig Fennessy at ACD, + 1 949 261 7533 or cfennessy@acdcom.com.

Economizing Process Vaporizer (EPV) to be installed in Brazil

Economizing Process Vaporizer (EPV)



In early 2011, **Wittmann** will commission its first Economizing Process Vaporizer (EPV) as part of a Wittmann CO₂ Generation System being installed at one of the world's leading soft drink bottling plants in Brazil. This EPV is the first of a new line of "energy efficient" vaporizers designed to vaporize CO₂ using heat from recovered or generated CO₂ streams. The new EPV will reduce the bottler's system refrigeration load by up to 93 kW per metric ton of CO₂, without the need for any supplemental electricity, steam, or secondary heat source for liquid CO₂ vaporizing.

The vaporized CO₂ demand is controlled and supplied by the fully automatic EPV. If additional vaporized CO₂ is required, it is automatically drawn from the existing electric, water or steam heated vaporizers.

The EPV is compact and can fit in a space as small as 1.25 m². Because it is so compact, installation costs are low. The unit has no electrical heating elements and few moving parts, so maintenance is minimal.

The attractive pricing of the EPV will allow most users to see a positive return on investment (ROI) in less than one year.

For more information contact Bill Geiger at Wittmann,
+ 1 386 445 4200 or BGeiger@wittmann.com.



Fuel Fired Water Bath Vaporizers: “New tricks for an old dog”.

A review of the many diverse new features and applications for the Cryoquip VFTU Series

The VFTU Series is a fully-engineered, automatic vaporization system which has been an important part of Cryoquip's range of heat exchanger systems for many years. VFTU products are designed to provide reliable service in the full range of modern day process and back-up applications.

Each VFTU unit provides fuel fired vaporization capacities to 5,000,000+ standard cubic feet per hour (131,500 NM³ / HR) for liquid Nitrogen (LN₂), Oxygen (O₂) and Argon within a single system. The water bath tank, process bundle(s), burner system, and controls are all contained in one package with no external piping or boilers and are rated for full outdoor duty. The VFTU Series vaporizer can be designed for other cryogenic fluids such as LNG.

A recent project had some unique requirements, which included a stacked installation, low noise criteria, and a triple redundancy in control logic permissives. VFTU's are typically installed at ground level, however space limitations required this customer to install one unit on a platform above another unit at ground level. The customer wanted reduced noise, which was accomplished by installing noise abatement materials, blower silencers, and noise reducing blower jacketing which are optional features on the VFTU Series.

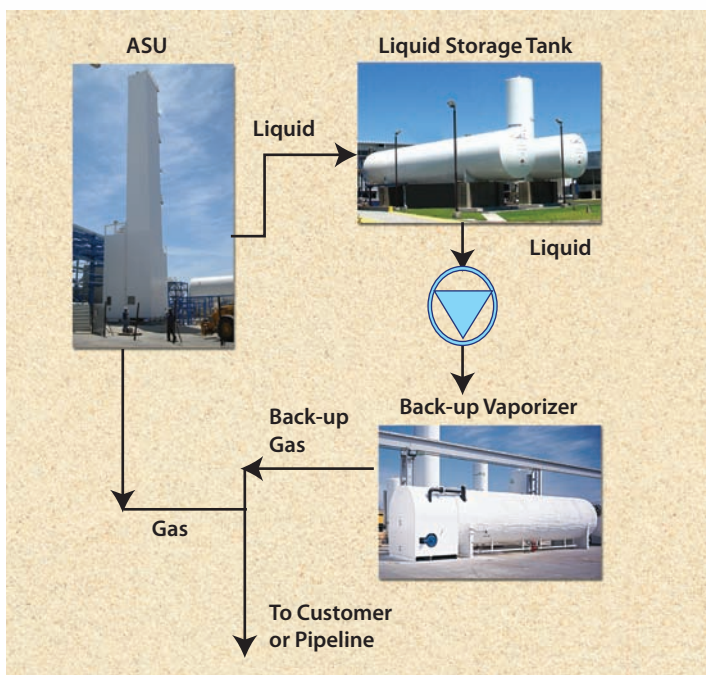


Figure 1

The VFTU Series can be used as a process or a back-up system vaporizer (see Figure 1), providing backup system for an ASU, to produce gaseous nitrogen, oxygen, and argon, as seen in the diagram. The gas is fed directly to the customer or to a pipeline and a back-up supply of liquid nitrogen, oxygen, and argon is stored in cryogenic storage tanks. When the ASU goes off line (either due to malfunction or maintenance), the liquid is pumped from the storage tanks through the VFTU backup vaporizer to maintain a seamless supply.

VFTU units are used in the manufacturing of steel, chemicals, and electronics, and other products.



Multiple exchanger bundles can be incorporated within the same system to accommodate multiple process streams, pressure builders, waste streams and specialty mixes. The VFTU Series is designed to accommodate any combination of these bundles running at any one time and at any flow turndown for maximum flexibility. The removable process bundles are made of stainless steel U-tube construction containing unique SPIRO-VANES, which promote highly efficient vaporization. U-tube construction results in low stress cryogenic design and long service life. Process bundles are provided to all world-wide pressure vessel code certifications. Standard is ASME Section VIII, Div. 1.

Emergency ballast water volume can also be included within the design such that up to 30 minutes or more of process runtime can be provided, even if the burner system is disabled due to fuel or electrical power interruption. Extended water ballast volumes provide emergency operation time without any utilities.

The VFTU includes the latest in automated burner flame safeguard controls and fuel trains to meet NFPA 85, FM (Factory Mutual) and IRI (Industrial Risk Insurer's) codes. The standard flame safeguard system, designed by Honeywell, has an Expanded Annunciator for pinpoint troubleshooting and burner status. The complete burner system is housed in the tank end-mounted burner shed with access doors for added protection from weather elements in harsh environments. A central NEMA 4 control panel is located on the outer burner shed wall. Whether used as a pipeline back-up supply or as the prime process vaporizer, the VFTU Series offers the reliability, package design and capacity range to meet most any need.

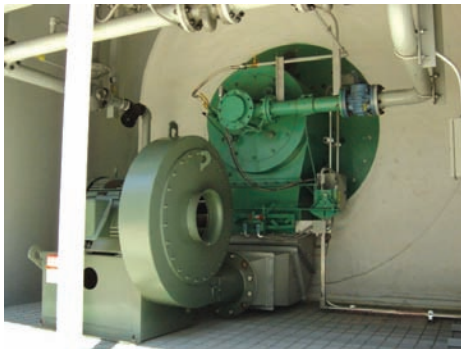


Figure 2

Some standard VFTU features include a completely pre-wired and assembled system in one integral package with integral burners, process bundles and controls. Burner choices include single 100%, dual 100% or dual 50% burner system packages (see Figure 2). There is also an efficient integral fire tube heat transfer design with nominal efficiencies of 80% for low fuel cost consumption.

All VFTU units undergo full-fire functional testing at Cryoquip factory prior to shipment. They also come with remote alarm status via dry-contact.

Optional VFTU features include -

- Low NOx emissions for the most stringent worldwide emissions locations
- Severe duty motors can also be used for the blowers and water circulation pump
- Dual 100% redundant and independent burners can be installed for maximum back-up reliability
- Expanded remote annunciation options of Data Highway RS-485 link (MODBUS)
- Blower silencer options are available for reduced noise level locations
- Hazardous area ratings are available for Class 1, Div 2, Grp D locations.
- Burner fuels are natural gas and propane gas.

Cryoquip also offers a very special VFTU design which is used for acoustic horn testing within the aerospace industry (see Figures 3, 4, and 5). Acoustic horns are strategically placed around a test room with the test specimen in the center. While table shakers are typically used for simple vibration testing, acoustic horns are able to create vibrations across extreme spectrums from various angles to simulate more complicated scenarios such as payloads on a rocket or shuttle launches. Gaseous nitrogen at a specific flow and temperature is passed through the horns to create intense noise for vibration testing. The discharge temperature tolerance of the nitrogen is extremely important for the horns to work properly. To achieve this tight tolerance of $\pm 5^\circ \text{F}$, a cold water bath temperature design is used, which requires an intricate internal icing design. Our specially designed VFTU vaporizers are ideal for this application because they offer large-scale vaporization and the required colder exit temperature control in a single package.

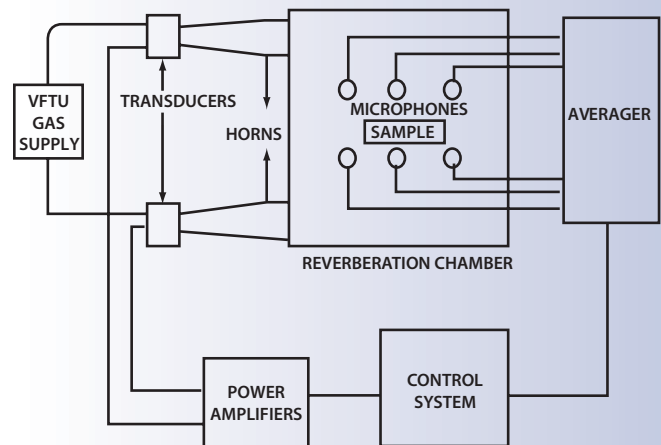


Figure 3 (Courtesy JPL)



Figure 4 (Courtesy JPL)



Figure 5 (Courtesy of Integration and Testing Laboratory, INPE, Brasil)

For more information contact Paige Lewis at Cryoquip.
+ 1 951 677 2077 or plewis@cryoquip.com

Cryoquip Australia and CSIRO Create New Liquid Nitrogen Dewar Filling Station Designed To Safely Work In Confined Areas

Introduction

CSIRO (Commonwealth Scientific & Industrial Research Organisation) created a new Dewar Filling Station for use inside buildings. The new filling station includes automatic Liquid Nitrogen (LN_2) filling control, as well as monitoring and shutdown systems safety mechanisms.

LN_2 is commonly used in the microscopy laboratory environment, and can cause significant health and safety risks, such as asphyxiation, explosions, burns and/or frostbite from splashes and other injuries. Several workplace fatalities have resulted from nitrogen exposure.

One nitrogen exposure incident occurred CSIRO Livestock Industries' Australian Animal Health Laboratory (AAHL) in 2001. AAHL is a high security, bio-containment facility having a number of airtight laboratories. In airtight environments, the risks associated with handling LN_2 are significant. Even small spills or leaks can be life threatening as oxygen is rapidly displaced by the vaporizing LN_2 . The CSIRO team worked closely with Cryoquip Australia, a supplier of cryogenic handling systems, on possible design solutions. The outcome was a practical and effective Liquid Nitrogen Dewar Filling Station.



Figure 5: Overall view of LN_2 Dewar Filling Station. The Dewar is placed on a metal tray, where the weight of the Dewar is monitored. The metal tray is also equipped with a temperature sensor (white arrow), which will cease the flow of LN_2 in the event of a spill.

Dewar Filling Station Safety Features –

- Weigh scale recessed into floor, eliminating trip hazards when moving Dewar in and out of the Filling Station.
- Dewars are labeled with a unique barcode and a barcode scanner identifies the individual size and weight. Filling commences when a Dewar is properly positioned and the station monitors and continues to fill until a pre-programmed weight is achieved.
- Programmable Logic Controller (PLC) provides safety instructions for filling, the status of the fill process, and alarms with actions to be taken in the event of an emergency.
- Alarmed automatic shutoff valves close supply when an overflow or spill of LN_2 is detected.
- Interlocks on filling hoses ensure correct filling hose is released for coded open or pressure Dewars.
- Station door interlocks, monitored by the PLC, prevent filling if open.
- O_2 monitors activate room lock out when O_2 concentration falls below 20%.
- Power failure protective shutdown.
- Emergency stop button allows staff to manually shut off the LN_2 filling process.

For more information contact Andrew May at Cryoquip Australia, + 61 3 9791 7888 or amay@cryoquip.com.au



Figure 1: Pressure Dewar filling, demonstrating LN_2 gas venting into ceiling duct. Photo shows filling valves (red tops), temperature sensor (silver), and gas vent valves (green).



Figure 2: Entry procedure to LN_2 filling room. Only trained personnel are permitted access during restricted hours. The room locks out when O_2 level fall below 20%.



Figure 3: Barcode scanner recognizes the individual Dewar and its pre-programmed fill weight.

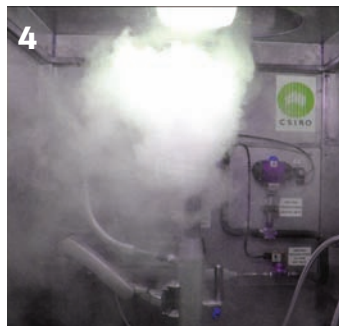


Figure 4: Open Dewar filling, demonstrates LN_2 gas venting into ceiling duct direct from cyclone filling head on a pivot swing arm.

Droplet Trajectories in a Turbine Rotor

The study of droplet trajectories will help to improve the design of blade profiles and provide more accurate performance calculations of **Energent's** Variable Phase Turbine (VPT)*. Past design practices assumed the impact of all droplets; we are now looking at the impact difference of small versus large droplets.

Figure 1 indicates the likely paths of large droplets ($> 25 \mu\text{m}$) moving through the blade passage of the VPT. Nearly all of the droplets impact the blade surface, separating from the two-phase flow. Losses are encountered due to the momentum loss of the impact at an angle with the surface and due to friction losses in the liquid film as it flows along the surface. The smaller the droplet the more it will follow the flow of gas.

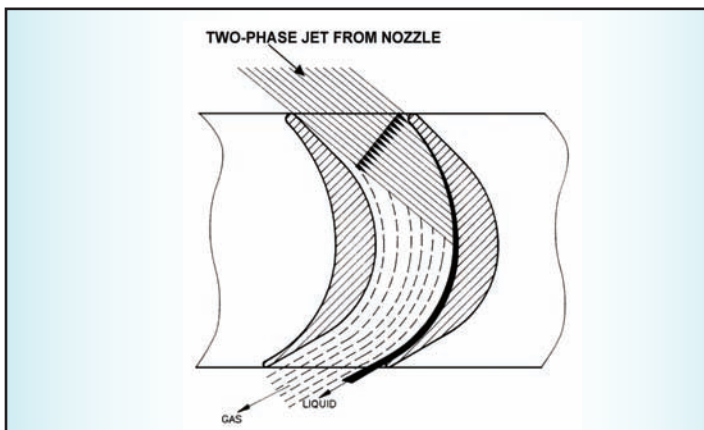


Figure 1 Schematic of large liquid droplets moving through the blade passage of the VPT.

By modeling the droplets as solid particles, their trajectories through the turbine rotor were calculated using CFD software from Numeca.

Figure 2 shows the location of the boundary of the inlet and the mid-span surfaces with respect to the rotor blade. Noting where the boundary of the inlet surface is relative to the blade will help you understand the plots on the right side in later figures.

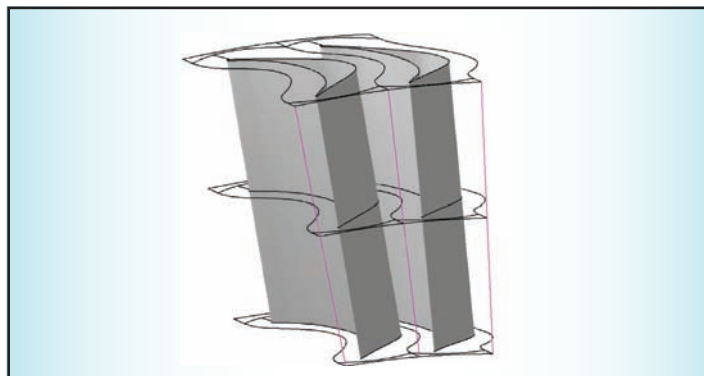


Figure 2 The location of the inlet and mid-span surfaces.

The left side of Figures 3 - 6 shows the trajectory of particles that start on the inlet surface at mid-span. The trajectories of droplet diameters of 1 and 10 microns, typical of cryogenic and refrigerant flashing expanders, are shown. For each diameter, the trajectories were calculated both ignoring and including the effect of the gas flow turbulence on the particle trajectory.

The right side of these figures shows the variable "Destination_outlet," with a range between 0 and 1. "Destination_outlet" is the fraction of the droplet trajectories that start on the inlet surface and leave through the outlet surface. 0 indicates that the particles hit a wall: hub, shroud or blade. 1 means that the particles moved through the blade passage without hitting a wall. The consequence of including the effect of the gas flow turbulence on the droplet trajectory is that all the particles that start at a particular point on the inlet surface do not follow the same trajectory. This is reflected in the intermediate values of "Destination_outlet".

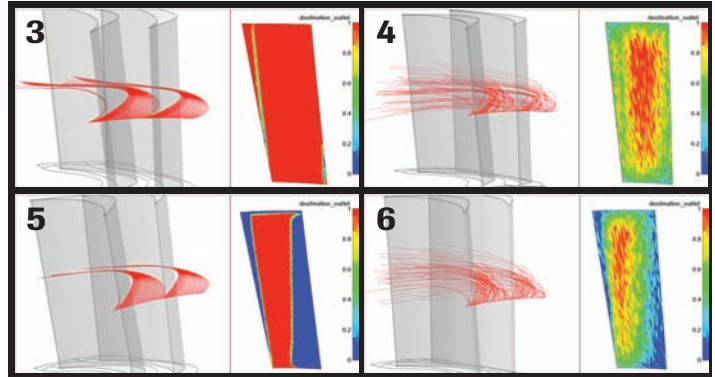


Figure 3 1 micron particles without turbulence.

Figure 4 1 micron particles including the effect of turbulence.

Figure 5 10 micron particles without turbulence.

Figure 6 10 micron particles including the effect of turbulence.

For the 1 micron diameter, the narrow strip where the variable destination_outlet is not equal to 1 corresponds to the droplets that hit the leading edge and pressure surface of the blade.

The larger diameter droplets are more likely to hit a wall than the smaller ones which are more likely to follow the gas flow. The effect of turbulence on the droplets is to scatter them. Fewer reach the outlet without hitting a wall.

For the conditions analyzed, including the effect of turbulence, the results show that only 27 % of the 1 micron droplets impact the surface whereas 50 % of the 10 micron droplets impact the surface.

Figures 7-8 show the average impact angle of particles hitting the blade wall, measured from the plane tangent to the wall. For both sizes, the droplets impact the same region of the blade surface on the pressure side and at the leading edge.

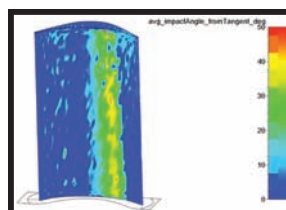
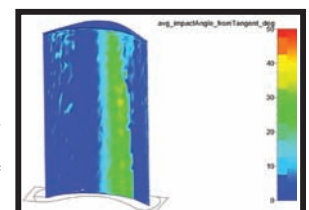


Figure 7 Average impact angle for 1 micron particles on the blade surface, including the effect of turbulence.

Figure 8 Average impact angle for 10 micron particles on the blade surface, including the effect of turbulence.



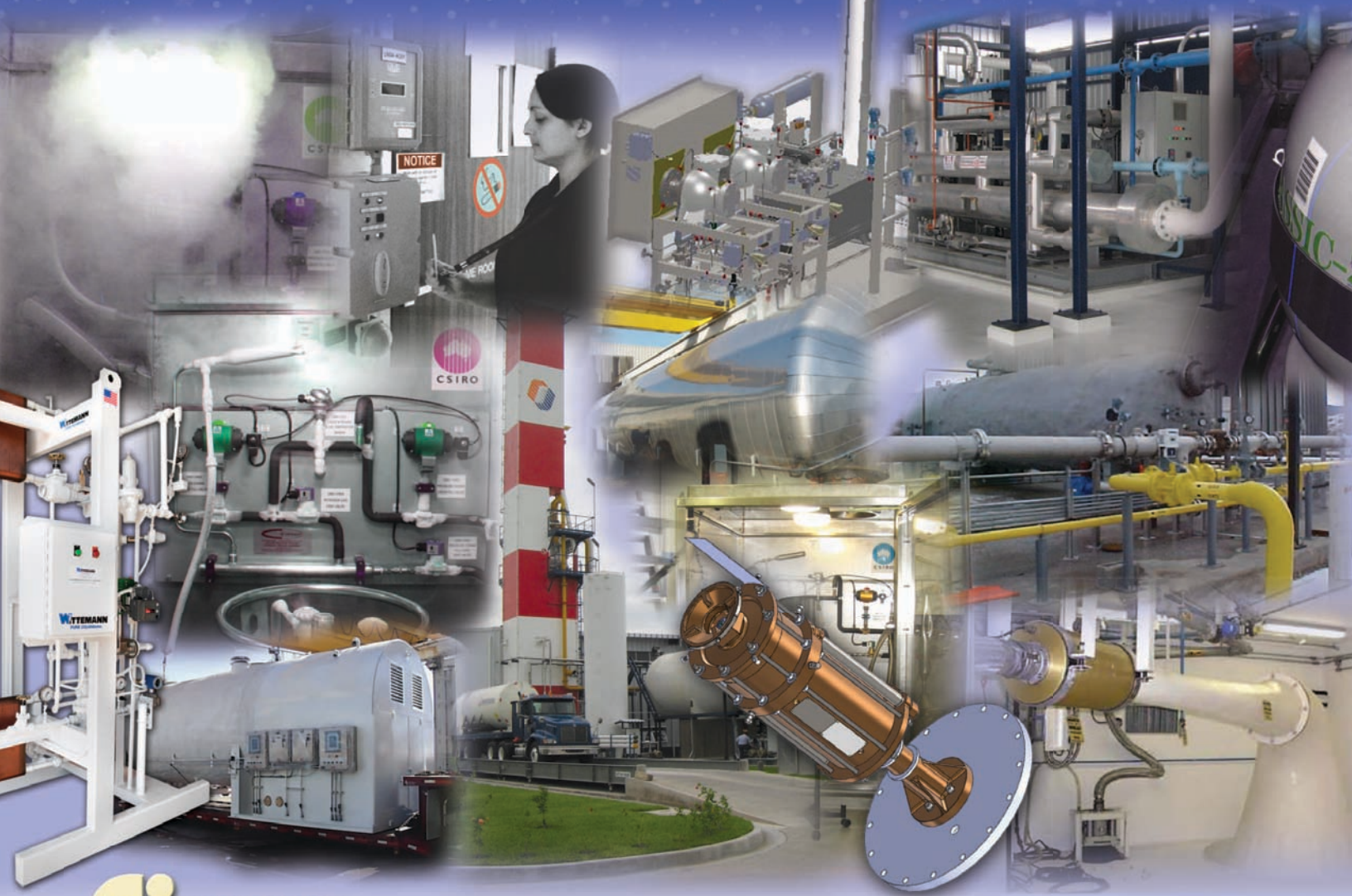
For more information contact Ron Franz at Energent
+1 949 261 7533 or rfranz@energnet.net.

* Lance Hays, "The Energent Variable Phase Turbine expands liquids or supercritical fluids used in refrigeration," FrostByte, Summer 2009, pages 1, 4.



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25720 Jefferson Avenue
Murrieta, CA 92562-9524 USA



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