Nikkiso Clean Energy and Industrial Gases Group

Your global choice for innovative equipment and solutions in liquid gases and beyond.

LNG Products Edition

NIKKISO

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LNG Products Edition

Nikkiso Cryogenic Industries Group Announced its Consolidation

On March 4, 2019, Cryogenic Industries, Inc. and Nikkiso Cryo, Inc., subsidiaries of Nikkiso Co., Ltd (Japan), announced their functional consolidation as “Nikkiso Cryogenic Industries Group” (the Group). Consisting of Nikkiso Cryo, Inc. (Las Vegas, NV) and Cryogenic Industries, Inc. (Temecula, CA) and its subsidiaries, ACD, LLC, Cosmodyne, LLC, and Cryoquip, LLC, the group will provide innovative equipment and solutions in liquid gases and beyond.

The Group’s creation involves the strengthening and development of five functional units of the companies. The Cryogenic Pumps unit aligns ACD’s and Nikkiso Cryo’s lines of pumps. The Cryogenic Process Systems unit incorporates turbo expanders along with LNG and Air Separation plants. The Heat Exchanger Systems unit focuses on cryogenic vaporizers, LNG and industrial gas equipment. The Cryogenic Services unit provides service and support through a broad network of global facilities. A newly created Integrated Cryogenic Solutions unit will allow for centralized management of product and project development across channels and in multiple market segments. Through joint research and innovation, the Group will provide increased engineering and systems solutions for market development.

“One key benefit of our new business approach is the capacity to expand our offerings and provide a comprehensive product line for clean energy such as LNG and hydrogen, in addition to our existing line of products for industrial gases,” said Peter Wagner, President and CEO of Cryogenic Industries. “We are looking forward to working together with Nikkiso Cryo as Nikkiso Cryogenic Industries Group, with our shared experience, resources and commitment to quality. This will allow us to focus more closely on our customers’ needs, providing individual support, service and solutions.”

The functional consolidation will provide the opportunity for a more expansive look at the customer’s product experience and extend the Group’s global reach across increased markets. The full integration will take place over the next several months.

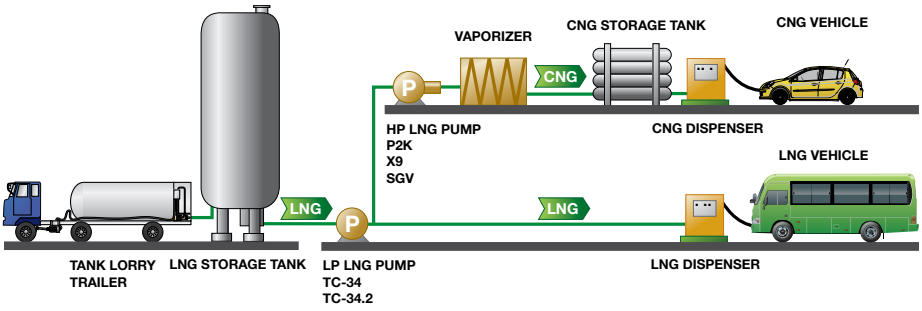
NIKKISO ACD

A leading manufacturer of reciprocating and centrifugal pumps for all cryogenic liquids and turbo expanders for air separation.

Liquefied Natural Gas.

ACD offers a wide range of cryogenic fuel supply pumps to accommodate various flow and pressure requirements for LNG fueled gas engine systems, bulk transfer, off-loading, and bunkering.

Each centrifugal and reciprocating pump is specifically designed to meet LNG or CNG applications while providing both efficient operation and extended product life. Cryogenic, hydro, and pneumatic testing during the assembly phase ensure that ACD pumps comply with industry requirements and match product performance guarantees.



Fueling Applications

- Rail/Locomotive (LNG)
- Marine (LNG)
- Bus (CNG & LNG)
- Light or medium duty truck (CNG & LNG)
- Heavy duty truck (LNG)
- Passenger car (CNG)
- LMT (LNG)

Pump Applications

- Fuel gas systems
- LNG high pressure feed to L/CNG station vaporizers
- Vehicle loading and trailer off-loading
- Bulk transfer
- Bunkering

L/CNG Station Operations

LNG Station	CNG Station	L/CNG Station
Fuel is brought in by transport trailers/tank lorrys	Fuel is supplied via local pipeline	Up stream same as LNG
LNG is stored in a cryogenic tank	Gas is compressed and stored in ASME tubes/bottles	LP pump provides boost for the HP pump
Vehicles are fueled using an ACD pump and single fill hose from dispenser	Vehicles are fueled by pressure differential from the storage banks/compressor	HP pump discharges HP LNG to vaporizer
		CNG from vaporizer goes into storage tank, dispenser to vehicle

TC-34.2 Pump.

Suction Pot Mounted Installation

The TC-34.2 pump has been specifically designed for operation in LNG with the most efficient set of hydraulic designs and lowest NPSHR in the industry. Key features of the design are the permanent magnet motors that are highly efficient and compact thus reducing the size and weight of the pump and wide operational capability through the use of a VFD. The modular multi-stage design allows to reach very high differential heads and the ratings vary from 2.5 kw to 250 kw.

Negligible bearing thrust loading is accomplished through the use of an active thrust balancing system resulting in extended bearing life. An innovative arrangement ensures wetted bearings and motor cooling during start up.

The pump is designed to operate in a sump or in-tank in a pump well and is available with a removal system that allows the pump to be removed from the LNG tank without having to empty the contents.

Specifications*

Differential Head	gpm	1 – 1,600
	lpm	4 – 6,056
NPSHR	feet	0.5 – 5
	meters	0.15 – 1.5
Differential Head	feet	50 – 4,000
	meters	15 – 1,220
Pump Design Rating	hp	3.35 – 335
	kw	2.5 – 250
RPM Range*	rpm	2,000 – 10,000

* Consult ACD engineering for actual ratings.

Features & Benefits

- Light weight and compact
- Small diameter lower cost in-tank pumpwell installation
- All parts are precision machined from aluminum forgings
- No castings, no defects, no re-pours, on time delivery
- Lower NPSHR, less than 0.5 M
- Dynamic thrust balance drum – long bearing life

Applications

- LNG feed to high pressure (L/CNG) pump
- LNG feed to natural gas engines
- LNG storage tank refilling
- LNG circulation
- Storage transfer and pipeline injection for LNG peak shaving plants
- LNG bunkering

Vertical Turbine Pump.

State-of-the-art Submerged Motor Pump VTK-240

The Vertical Turbine Pumps have been specifically designed for applications requiring high flow rates of LNG as well as meeting high differential head requirements. The VT pump line reaches efficiencies of over 70%. Because it uses a highly efficient permanent magnet motor the foot print is small thus reducing the overall cost of the installation, particularly in in-tank applications where the column diameter (pump well size) can be minimized.

The target market for this product line is LNG bunkering in all its different applications, from ship to ship, barge to ship or bunkering rail tender cars; flexible performance achieved through a VFD.

Specifications*

Flow Range	gpm	1,000 – 2,500
	lpm	3,785 – 9,462
NPSHR	feet	2 – 5 (162 – 2,800 gpm)
	meters	0.6 – 1.5 (613 – 10,598 lpm)
Differential Head	feet	46 – 1,937
	meters	14 – 590
Pump Design Rating	hp	167.5 – 335
	kw	125 – 250

* Consult ACD engineering for actual ratings.

Features & Benefits

- Highly efficient, over 70% – lower operating costs and heat input into the fluid
- Modular design, discharge pressure 60 PSI/stage – easily accommodates higher pressure requirements
- Compact design – minimizes pump well size resulting in lower overall installation cost
- High performance inducer – minimum NPSH requirements
- Dynamic thrust balance device – 15,000 hour bearing life design
- Electrical quick disconnect – ease of maintenance
- No Castings all machined parts

Applications

- LNG Bunkering
- Storage transfer and pipeline injection for LNG peak shaving plants
- LNG storage tank refilling
- LNG circulation
- Pipeline backup
- Send out

P2K Pump.

ACD's P2K reciprocating pump features a vertical design that offers less vibration, reduced noise, and a compact system footprint. Its cold end is submerged inside a vacuum-jacketed liquid sump, minimizing heat leak and increasing system efficiency.

Features & Benefits

- Vertical pump design eliminates gravitational loading on the piston, extending sealing ring life and providing smoother suction valve operation
- V-band clamp secures the sump to the intermediate, allowing quick and easy access to the cold end assembly
- External re-lubrication nipples for roller bearings and crosshead assembly provide extended life
- Motor positioned on the backside of the pumping skid eliminates possible fire, explosion, or hazard in the event of a liquid leak
- Replaceable crosshead wearband eliminates crosshead piston wear and reduces maintenance

Applications

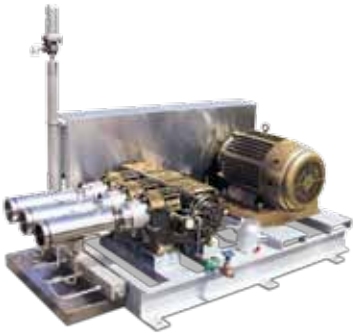
- Light duty high pressure LNG for L/CNG vehicle fueling

Specifications: standard P2K pumping systems*

Bore x Stroke	in	1.25, 1.50 x 1.50	1.75 x 1.50	2.00 x 1.50
	mm	(32, 38 x 38)	(44.5 x 38)	(50.8 x 38)
Flow Rate	gpm	1.13 – 3.10	2.20 – 4.20	2.87– 5.53
	lpm	4.27 – 11.73	8.32 – 15.89	10.90 – 20.93
Pump Design Rating	hp	7.5 – 20	10 – 20	15 – 20
	kw	5.6 – 15	7.5 – 15	11.2 – 15
Maximum Discharge Pressure	psi	6,000	4,500	3,500
	bar	414	310	241
NPSPR	psi	2	2	2
	bar	0.14	0.14	0.14
Maximum Suction Pressure	psi	300	300	300
	bar	20.7	20.7	20.7

* Contact ACD for additional P2K pump ratings.

SGV Pump.



ACD's SGV reciprocating pump has become the industry's leader for LNG high pressure and high flow applications. With its large 50 mm bore (1.97 inch) cold end, the SGV can achieve flows up to 25 gpm (95 lpm) at 6,000 psi (414 bar). SGV models are available in complete skid systems with auxiliary piping components included to ensure safe, reliable, and efficient LNG pumping. This compact, modular pump is available in single, double or triple cylinder configurations for a wide range of flow options.

Specifications

Bore x Stroke	in	1.25 x 1.38	1.625 x 1.38	1.97 x 1.38
	mm	(32 x 35)	(41 x 35)	(50 x 35)
Flow Rate	gpm	0.94 – 15.3	1.6 – 25.9	2.35 – 38.1
	lpm	3.56 – 57.9	6.1 – 98.0	8.9 – 144.2
	LH_2 gpm	0.90 – 10.8	1.52 – 18.3	2.25 – 26.9
Pump Design Rating	hp	15 – 200	10 – 200	10 – 200
	kw	11 – 150	11 – 150	11 – 150
Maximum Discharge Pressure	psi	10,000	6,000	6,000
	bar	690	420	420
NPSPR	psi	10	5	5
	bar	0.70	0.35	0.35

60 HZ performance

Features & Benefits

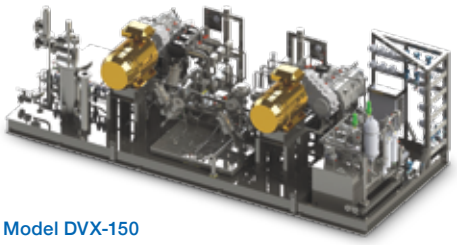
- Modular, compact displacement pump (available in 1, 2, or 3 cylinder configurations) provides a wide range of flows
- Vacuum-jacketed cold end for minimal cool-down losses and low NPSHR
- Pressurized, oil-lubricated drive with oil pump and reservoir allows higher bearing loads and prevents internal leakage
- Optimized cold end packing assembly increases seal life

Applications

- High pressure LNG for L/CNG vehicle fueling
- ME-GI fuel gas system fueling
- Locomotive fueling pump

MSP-3SL.

TOTE, Marlin Class Containership.
ACD's DNX-200 used (USCG compliant)



Model DVX-150

High Pressure Fuel Pump System

Over 50 LNG fueled ships operate with ACD pumps, more than any other brand

- Class approvals ABS, DNV, LR
- Designed for cargo & containerships
- Meets all ME-GI requirements
- Actual operating experience

ACD's Class Approvals

ABS

BUREAU VERITAS

DNV·GL

Specifications

Flow Rate	1 – 31 m³/h
Pressure	200 – 600 bar
Suction Pressure Req'd	4 bar (above saturation pressure)
Power Required	50 – 300 kW

Model	Dimensions (LxWxH)	Weight
DNS-150	220mm x 100mm x 1900mm	7,000 kg
DNS-200	220mm x 110mm x 1900mm	12,700 kg
DNX-100	6700mm x 2700mm x 1800mm	14,000 kg
DNX-200	5500mm x 2700mm x 2100mm	10,000 kg
DVX-150	6600mm x 2700mm x 2500mm	15,000 kg
SNS-150	3400mm x 2700mm x 1900mm	7,500 kg

Service and Support.

Installation, Commissioning and Service Support

- Class approvals ABS, DNV, LR
- Designed for cargo & containerships
- Meets all ME-GI requirements
- Actual operating experience

Annual Service Package – Basic

- 24/7 technical support via phone and/or email with dedicated contact information
- Standard exchange items:

Item/Assembly	Exchange Interval	Standard Cost (USD)	Additional Billing Apply**
MSP-SL Cold ends	3,000 – 5,000 hrs	Contact ACD*	Yes
Lube Oil Filters	Annual	Contact ACD*	No
MSP-34.2 Assembly	20,000 hours	Contact ACD*	No

* Wear parts and labor included
** May apply based on wear of non-standard exchange parts

- Training will be provided to ship technicians once per year for:
  - 3 training days
  - Installation and removal of cold ends, filters and submerged pumps
  - Normal operation of pump systems and trouble shoopting techniques
- 48 hour shipping of parts/cold ends from one of ACD's global service locations
- Non-Emergency Call outs

Global Network

ACD
ACD – Atlanta
ACD – California
ACD – Dubai
ACD – Houston
ACD – India
ACD – Pittsburgh
ACD Europe (ACD Cryo)
Cosmodyne
CryoCanada – Red Deer
CryoCanada – Toronto
Cryogenic Industries – China
Cryogenic Industries – Korea
Cryogenic Industries – Malaysia
Cryoquip
Cryoquip – Australia
Cryoquip – China
Cryoquip – India
Cryoquip – Malaysia
Cryoquip – UK
Rhine Engineering

NIKKISO COSMODYNE

A leading provider of natural gas liquefaction and hydrocarbon separation systems.

Cosmodyne LINEX Series Natural Gas Liquefiers.

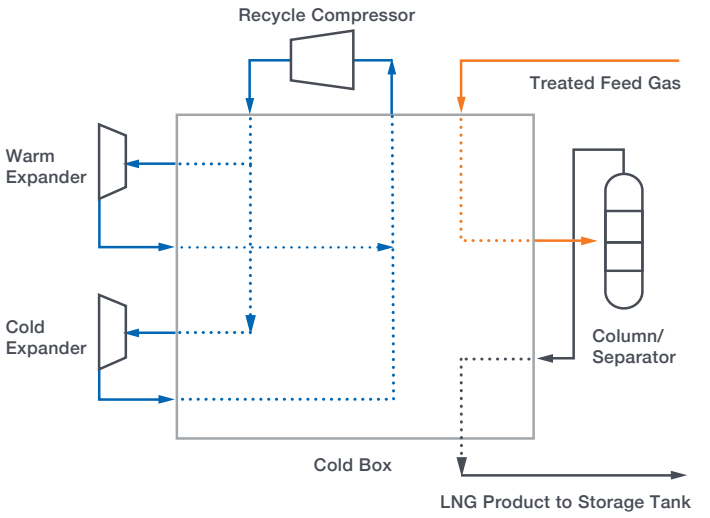
Simple. Reliable. Affordable.

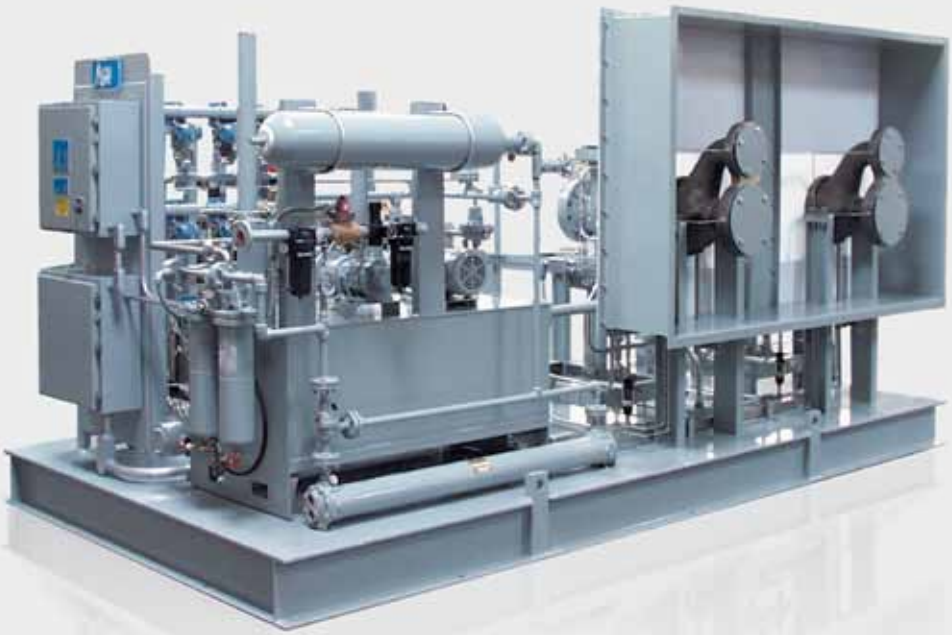
Cosmodyne LINEX series natural gas liquefiers set the standard for reliability, simplicity, and value. The safe, proven and environmentally–friendly nitrogen expansion cycle delivers unmatched operating flexibility to respond to changing production demands. The innovative and proven technology delivers excellent performance at the lowest cost per gallon. Each plant is a modularized skid-mounted system that is manufactured at Cosmodyne's US factory for standard over-the-road shipping and easy installation.

Applications

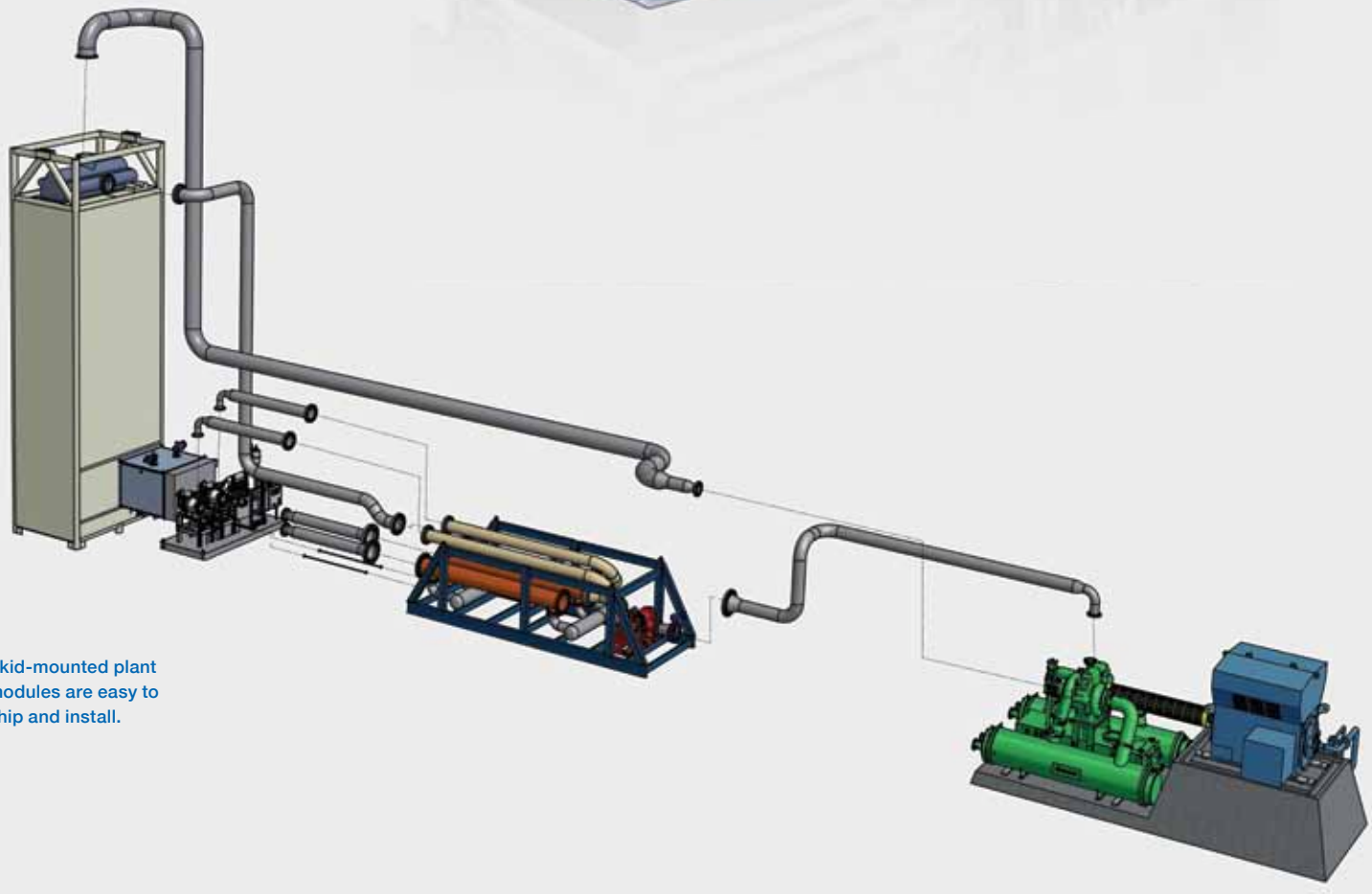
Cosmodyne LINEX systems are ideally designed for the new high horsepower users of LNG in the rail, marine, mining, trucking, and oilfield markets. Traditional users such as utility peak shaving, power generation, virtual pipelines, and commercial/industrial operations are also excellent fits for LINEX technology.

LINEX Process – Easy to Operate





Compact dual turboexpander skid by Affiliate company ACD.



Skid-mounted plant modules are easy to ship and install.

Is a Cosmodyne LINEX Plant Right for You?

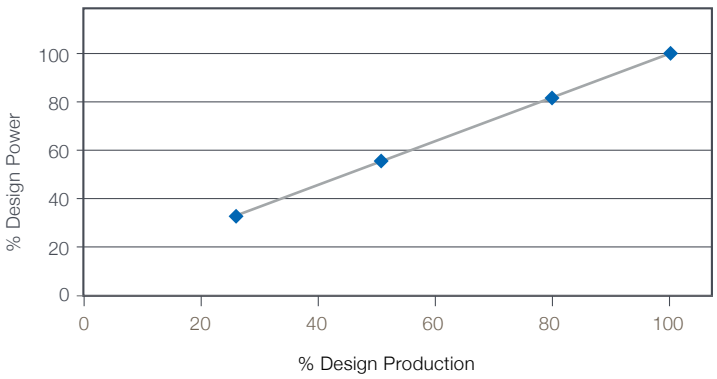
- CAPEX savings with lower cost non-hydrocarbon compressors and expanders
- OPEX savings from proportional turndown efficiency (up to 65% efficient turndown)
- Expandable for growing with the market
- Easier permitting & better environmental footprint due to no hydrocarbon emissions from refrigerant loop
- Inherent safety with inert, nonpolluting, corrosion-free nitrogen refrigerant
- LNG temperature control to eliminate tank boil-off gas
- Elimination of cost and complexity of storing, mixing and managing mixed hydrocarbons
- Simple and rapid return to service after shutdown
- Reduced operator training and education requirements
- Automatic efficiency boost when ambient temperatures fall
- Operation easily adapts to changing feed gas composition

Cosmodyne offers a complete series of solutions that are sized for typical customer requirements and market situations. We can also economically tailor the systems to meet other capacity requirements in addition to standard sizes. The LINEX line uses an efficient closed-loop nitrogen refrigeration cycle. The LINEX-OL utilizes open-loop liquid nitrogen for a low CAPEX, quick-to-market, small plant solution.

Optional Features

Cooling systems (evaporative, closed-loop or gas-to-air)
Feed gas pretreatment (water, Carbon Dioxide, others)
Gas drivers (gas turbine, engine)
LNG specification matching
Hydrocarbon separation
Trailer loading stations
Many more options tailored to customer requirements

Nitrogen Cycle Turndown Range



LINEX System Specifications

Model	GPD	MTD	MMSCFD
LINEX-OL	5,000 to 50,000	less than 85	less than 4.2
LINEX-60	60,000	100	5.0
LINEX-100	100,000	170	8.4
LINEX-250	250,000	425	20.9
LINEX-350	350,000	595	29.3

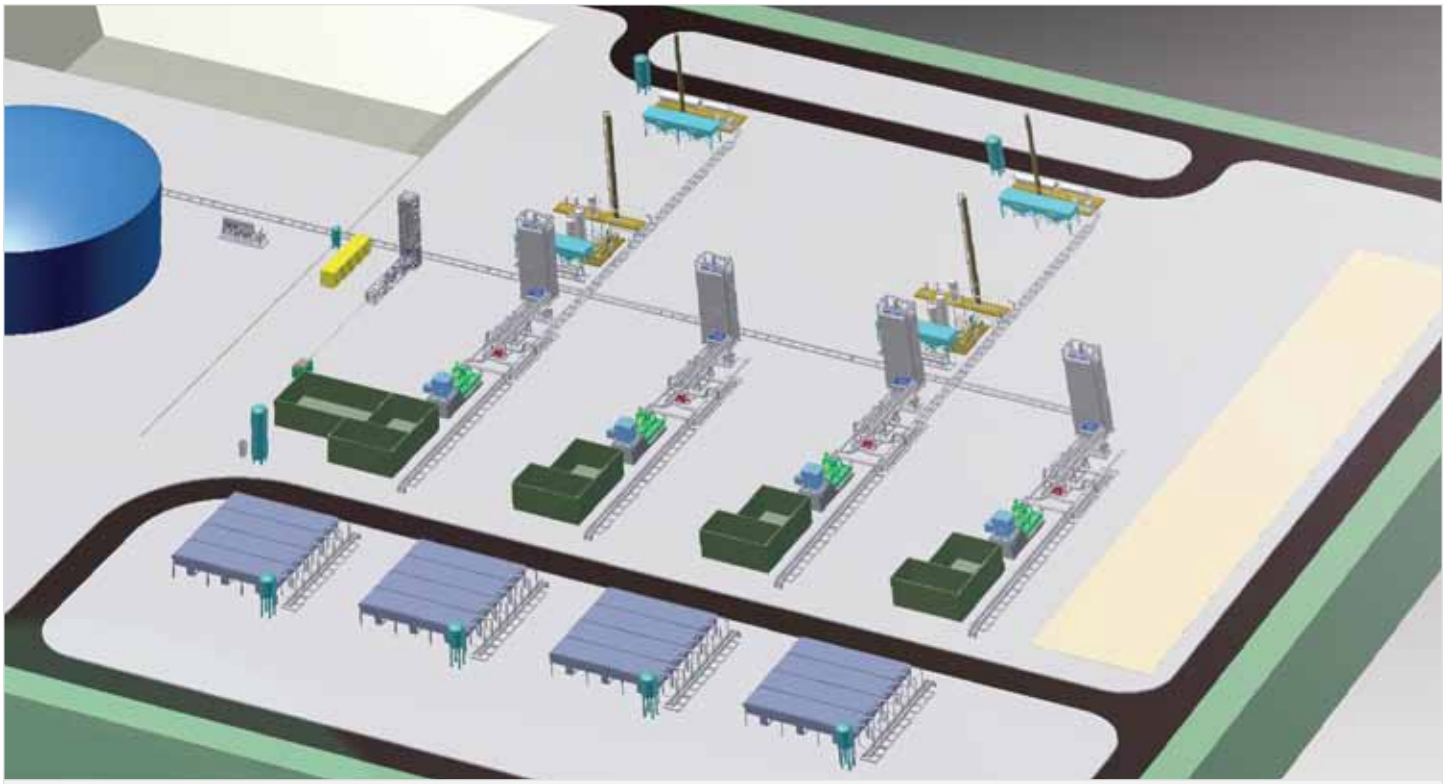
LINEX Installation Examples.

150,000 gpd installation. Gas Turbine driven Refrigerant Compressor.

Gas Turbine driven Refrigerant Compressor.

60,000 gpd installation with heavy hydrocarbon removal system.
Low pressure natural gas condensing system.

90,000 gpd installation with 1% ethane purity.



Cosmodyne LINEX Plants Easily Scales with the Market

About Cosmodyne

Cosmodyne is a leading manufacturer of cryogenic plants with more than 450 placed in operation around the globe since 1958. Cosmodyne natural gas liquefiers produce LNG as alternate fuel for high horsepower marine, rail, mining, trucking, and oilfield applications, virtual pipeline markets, and utility peak shaving. Cosmodyne air separation plants produce liquid and gaseous oxygen, nitrogen and argon. Cosmodyne is part of the Cryogenic Industries Inc. family of companies which include ACD LLC and Cryoquip LLC. For more information, visit www.cosmodyne.com.

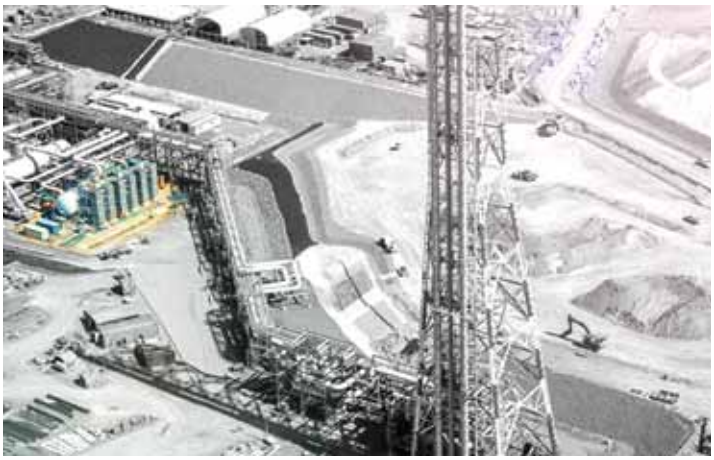
NIKKISO
CRYOQUIP

Providing full design solution capability with the latest heat transfer software and design experience using proprietary programs.

Built on Excellence.
LNG regasification systems and cryogenic equipment.

Terminals

LNG export and import terminals continue to be developed as the global demand of natural gas increases. These terminals allow nations to easily deliver natural gas to nations that are limited in fueling resources. Export Terminals, like the Sabine Pass LNG terminal in Louisiana, pull natural gas out of the existing pipeline and liquefy onsite into large storage containers. The liquid is then loaded onto a ship for transportation. On the receiving end, an import terminal stores and vaporizes the LNG for distribution into a natural gas pipeline. Cryoquip has an extensive line of LNG terminal vaporizers for all aspects of both the import and export terminal. LNG vaporizers, BOG heaters, fuel gas heaters, and flare vaporizers are among the Cryoquip products needed on any terminal.



Peak Shaving Systems

During extreme weather conditions, such as cold fronts and heat waves, the demand for pipeline natural gas increases to feed heating systems and power generation plants respectively. To meet these increased gas demands, the industry has turned to LNG peak shaving plants. LNG peak shaving consists of storing LNG onsite and regasifying to meet high usage needs. Cryoquip leads the industry, providing reliable vaporization solutions across the globe.

During these high demand “peak” periods, the stored LNG is re-gasified and added to the pipeline systems to ensure the requirements of consumption are met. Cryoquip’s vaporization technologies have been used for decades for these applications all around the world.

Marine

Marine vessels typically use a variety of fuels oils which are generally residual products of crude oil refining. The problem with this type of fuel is that it generates a variety of harmful pollutants. To counteract this, LNG is used to reduce the pollutants generated. Cryoquip has extensive experience with the marine fuel gas supply vaporizer for both dual fuel and LNG only vessels. These vaporizers carry the Cryoquip reputation for quality and meet or exceed marine class society design requirements. Along with engine fuel supply systems, Cryoquip has developed marine bunkering solutions for both barge and land based systems as well as turn key vaporization products for floating storage and regasification units (FSRUs)

Virtual Pipeline and Power Generation

A satellite LNG (virtual pipeline) system can be used when natural gas pipelines are unavailable bringing the gas pipeline to you. These systems can be used to transfer LNG from transport containers to onsite storage (by pressure feed or pump) re-gasify the LNG regulate/ odorize for end customer use. Each system is designed for the specific site conditions and can utilize a wide variety of utilities for the regasification process.

These systems can also be utilized for generators that use, or are converted to use, natural gas as a fuel source. Large scale virtual pipeline systems can combine Cryoquip‘s equipment portfolio or with ACD pumps for a complete turnkey package to support up to A 250 MW power generation system.

LCNG Stations

Liquefied natural gas (LNG) and compressed natural gas (CNG) have become a major fuel source for vehicles that reduce both emissions and fuel cost, leading to LCNG fueling stations becoming a pivotal infrastructure component. An LCNG station combines LNG and CNG stations using only LNG supplied by tanker trucks and stored onsite. Cryoquip has extensive experience with the Regasification needs for LCNG stations, incorporating fan assisted and natural draft ambient vaporizer designs for LNG saturation and CNG warming applications.

Mobile Regasification Systems

Many times the need for natural gas is temporary and in remote locations. As with stationary satellite LNG systems, these applications have no access to a natural gas pipeline or fueling infrastructure Applications may include generator fueling for drill sites, burner fueling for asphalt plants, or even re-injection into a pipeline during infrastructure maintenance/repair.

For such cases, mobile regasification systems are paramount Taking all of the same concepts of the satellite LNG systems, Cryoquip provides turn-key regasification systems for any need on a mobile platform. Whether it be on a dedicated transport trailer, or in an ISO-type frame, Cryoquip has the solution. Options include all piping, controls, trim heating, and even onboard generators for self contained power. Whatever the need, whatever the location, Cryoquip has the solution.

Well Stimulation/Fracking

The exploration and production sector of the oil and gas industry utilizes nitrogen frequently for a number of operations throughout the life of an oil and gas well. During the workover and completion operations, gaseous nitrogen is pumped into the well to displace fluid in the casing. This displaced fluid has a heavier density than the nitrogen, resulting in the nitrogen lifting the fluid. This nitrogen lifting is used to stimulate flow in the well, extending the well life. Similarly, nitrogen is mixed with cement and pumped into the annulus of the well, creating a foamed cement which is better at resisting stress cracks.

Our lines of direct fire vaporizer runs are the leading vaporizer on the fracking industry for high pressure nitrogen and LNG supply. the ADFV and NGFV series vaporizers are designed with safety in mind and come with a highly efficient vaporizer coil that provides the most capacity in the smallest footprint on the market. These vaporizers are extremely robust and versatile, coming in options to run on either diesel or natural gas.

For smaller nitrogen/LNG flows, Cryoquip's VWP product line makes the most use out of rejected heat. Simply tie a water/glycol line from the engine jacket water on your closest engine to utilize all the energy locally available for your vaporization needs.


NIKKISO
CRYO
The global leader in development,
engineering, manufacturing
and testing for over 30 years.
GROVE

Submerged Motor Cryogenic Pumps.

Unmatched Reliability, Quality and Safety

As part of the Nikkiso Company global organization, our “original technologies” provide our customers with the confidence in knowing they are receiving the latest technology and the highest standards of engineering available.

Located in North Las Vegas, Nevada, in the USA, Nikkiso Cryo offers a full range of submerged pumps for LNG, LPG, LEG, LN_2, liquid propylene and many other liquefied gases.

With design, production and test facilities in both the USA and Japan, sales offices in Las Vegas, Houston, London and Tokyo, Nikkiso Cryo offers prompt and full support for all of our customers worldwide.

Quality and Safety.

Strive to Achieve the Highest Level of Quality Possible

Nikkiso Cryo is committed to continuous improvement of our products and services and to meet or exceed the requirements of our customers. It is through this commitment that Nikkiso Cryo has developed a reputation as a loyal and trustworthy supplier producing a quality product known for its high reliability.

Certified to ISO 9001

Our internal corrective action system helps assure that any lessons learned are immediately corrected not only for the current project, but in all of our internal systems to ensure all future processes and designs are as trouble-free as possible. We believe that quality is a continuous process that requires us to never stop trying to improve.

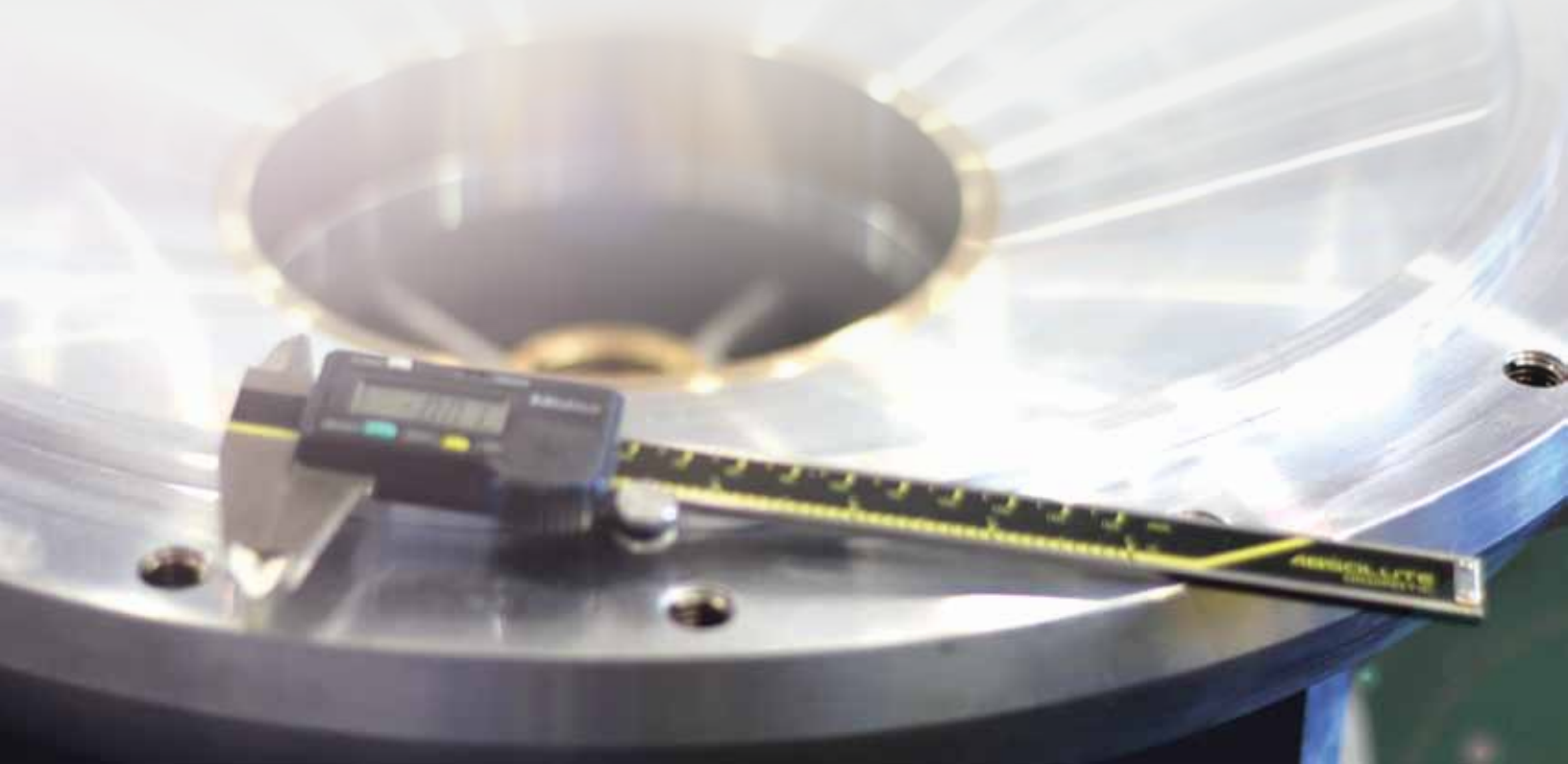

NIKKISO CRYO, INC.
ISO 9001:2008
SALES, DESIGN, MANUFACTURE, TESTING & SERVICE OF PUMPS
ANAB

Submerged Motor Pump Design Provided High Level of Safety

With the motor submerged in the pumped fluid, where no oxygen is present during operation, the submerged motor pump design provided by Nikkiso Cryo provides the highest level of safety.

The design uses a common shaft between the motor and the pump section that removes the need for a rotating seal, which eliminates the possibility of hazardous gases leaking into the atmosphere.

In addition, the terminal header, which provides connections for the power cables to penetrate through a static seal from the pumped fluid to the external conduit section, is certified for use in hazardous areas for the safest installation possible.



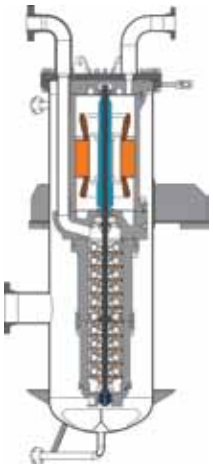
A Full Range of Pump Solutions.

Suction Vessel Mounted Pump

This design is provided with the pump and suction vessel which become an integral part of the piping system with external suction and discharge connections. The pump is mounted to the top or headplate of the vessel such that the pump, motor and fluid product are totally contained within the pressure vessel.

Shaft seals are eliminated. The pump inlet is below the suction vessel inlet which allows the source tank liquid levels to be lowered to a minimum.

The suction vessel also serves to allow entrained vapors to be separated and go through the vent line of the vessel and not into the pump. Removal of the pump requires only that the suction and discharge valves be closed with subsequent purging of the suction vessel. The pump is then removed by unbolting the top flange.

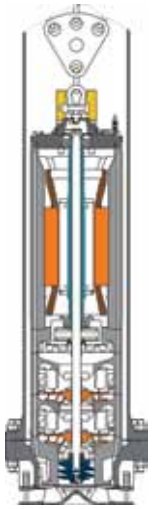


Removable In-Tank Pump

Removable, or in-tank pumps offer the advantage of overhead removal and installation without taking the tank out of service. The pump operates at the bottom of a purpose-built pump column through which it is installed and removed. The column provides the fluid discharge from the pump to the top of the tank and contains the lifting cables as well as the power cables.

When lowered into position, the pump is seated on a conical seat in the suction or “foot” valve at the bottom of the column. The weight of the pump opens the spring loaded foot valve, allowing the pumped fluid to enter the pump inlet where it is
then pumped to the top of the column and out through the discharge piping.

When the weight of the pump is removed, the foot valve closes, and the column can be purged and the pump safely removed. This design eliminates the need for piping connections below the tank liquid level for a very safe installation.

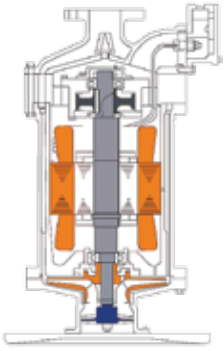


Fixed In-Tank Pump

This pump type is mounted directly to supports in the bottom of a storage tank, and connected to a discharge pipe which extends to the top of the tank and out to the discharge piping.

This simple and low cost design is primarily used in liquefied gas carriers and in any other application where removing the liquid from the tank for maintenance is a normal or required process and can be accomplished without excessive costs to the tank or system.

This design is ideal for smaller, horizontal storage tanks providing a totally submerged pump and motor that has no bottom penetrations providing a safe, leak-free installation.

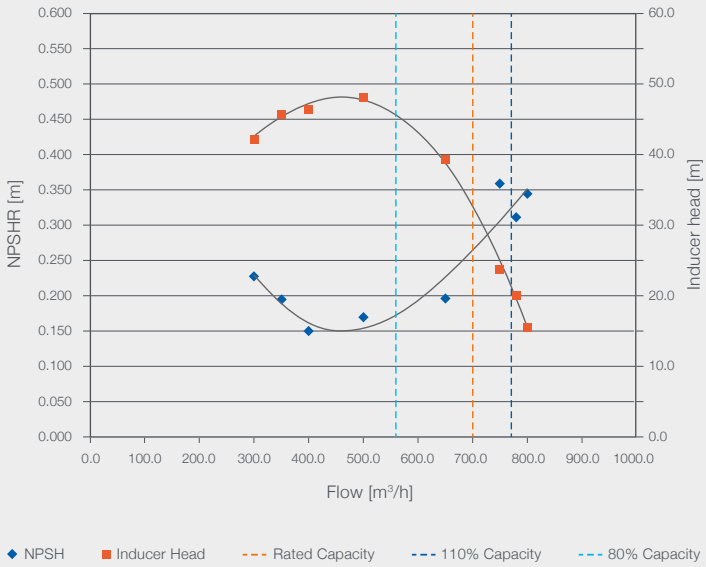


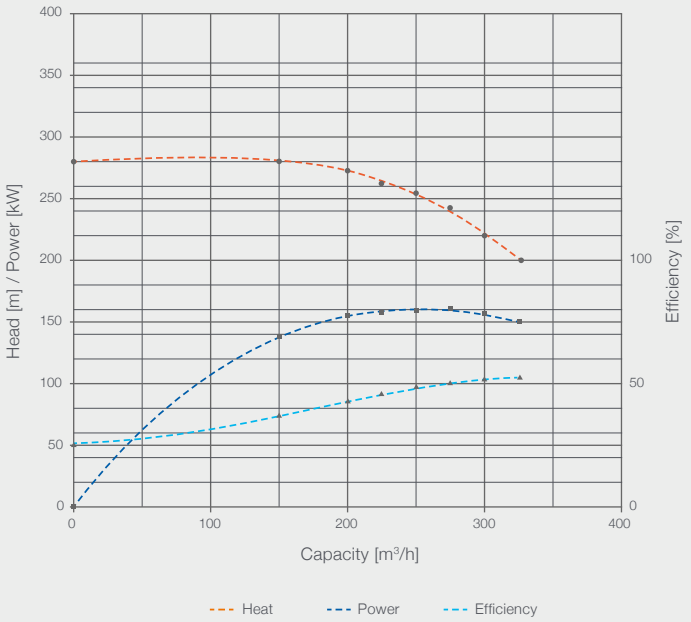
State of the Art Inducers.

Specially developed with high speed inducer technology from the aerospace industry, the inducers allow the pumps to reduce liquid levels to extremely low levels.

For pumps operating in liquefied gases, where pressures and temperatures of the pumped fluid are sometimes near their boiling point, the use of inducers in the pump inlet is necessary to ensure adequate NPSHR or Net Positive Suction Head Required, is supplied to the main centrifugal impellers. Nikkiso Cryo uses low solidity fan-type inducers as well as high solidity spiral-type inducers depending on the application. These inducers with high suction specific speeds, provide excellent low suction pressure performance over a wide flow range.

For applications which require tank levels to be minimized as much as possible, Nikkiso Cryo has developed a spiral inducer with very high suction specific speeds. Our ZEN—Zero Enabled NPSH—Inducer was specially developed based on high speed inducer technology from the aerospace industry to allow the pumps to reduce liquid levels to extremely low levels, which maximizes usable tank volume.





Innovative Systems.

Vibration Systems

As a result of our research and development team and through our Aftermarket Service organization, operating personnel can be trained to interpret data acquired from the condition monitoring system. Nikkiso Cryo's research and extensive experience allows for correlation of monitoring specific vibration modes with specific operating and wear conditions. Condition monitoring and trend analysis has the potential to provide more complete diagnostic information on an operating pump than physical inspection of the disassembled pump. This facilitates optimum timing of maintenance considering factors of reliability, operation and costs. Condition monitoring permits scheduling maintenance only when essential and indicates the need for immediate maintenance to prevent outages and loss of production.

Monitoring Pump vibration is an excellent means to determine pump condition; however, this is particularly challenging for submerged motor cryogenic pumps which have no exposed surfaces or shaft for making direct measurements from the outside of the containment vessel. Nikkiso Cryo can supply piezoelectric accelerometers designed for use directly submerged in the pumped liquid, mounted on the pump housings, and can also locate accelerometers on the outside of suction vessel mounted pumps to provide monitoring of pump vibration. These sensors can measure pump acceleration vibration directly and, with signal conditioning, provide velocity and displacement amplitude data. The condition of internal parts and the extent of wear can be determined by trend monitoring and frequency analysis.

Electrical Systems

As a supplier of submerged motor pumps operating in hazardous environments, Nikkiso Cryo has extensive experience in the selection and design of the proper electrical components to ensure a safe and certified system. These systems can be purged with nitrogen gas to remove moisture from the boundary section between cold and warm, and the purge gas pressure can also be monitored to determine if leakage exists. Electrical systems are supplied to meet plant specifications as well as US, European and any other international codes as required. The systems supplied by Nikkiso Cryo are of the highest quality and are fully tested prior to shipment to ensure the highest level of reliability.

Testing and Reliability.

Nikkiso Cryo offers performance testing at full speed, power and flow using LNG, LPG or LN_2 at our facility in Las Vegas, Nevada, or using LN2 at our facility in Tokyo, Japan. The pumps undergo rigorous testing throughout the flow range, with flow, pressure, motor power and many other measurements taken using calibrated systems to ensure compliance with project requirements.

NPSH as well as complete pumpdown can be measured as well as axial shaft position to ensure the thrust balance system is performing as designed.

Testing is performed to very strict Nikkiso Cryo standards in addition to API, ASME and other international standards and project requirements. Factory performance testing ensures that each and every pump meets exacting standards and provides trouble-free performance once it has been installed and is operating at the customer's site.

Reliability – Second to None

As a result of unique design features that control bearing loads and our multiple bearing technology, Nikkiso Cryo pumps provide unparalleled reliability. In many cases, mean time between overhauls **exceeds 20,000 hours**, with some pumps recording **more than 40,000 hours**.

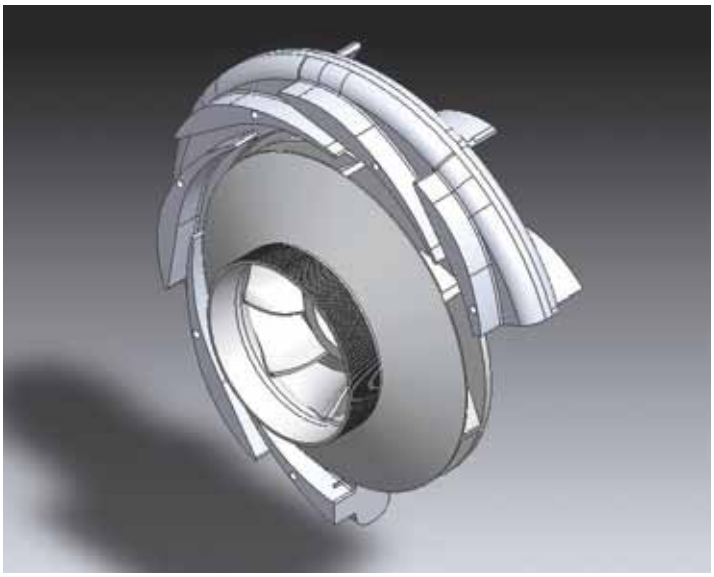
Global Service and Innovation.

Nikkiso Cryo Global Services

- Installation, commissioning and repair
- Technical training
- Spare parts management
- Engineering, failure analysis

With field service staff located in the USA and Japan, and with the support of our factory engineering staff, Nikkiso Cryo is focused on responding to all service needs with a sense of urgency and commitment. We recognize that downtime at our customers' sites results in losses of productivity and revenue, and we strive to provide the most prompt and efficient service possible.

Our experienced Aftermarket Services Group can provide all of your service needs, with supervisory services from initial installation, commissioning, maintenance, repairs and training, to assist with spare parts management and operational procedure review.



Nikkiso Cryo Innovation

- Exclusive horizontal assembly process for large, multistage high pressure pumps, reducing the need for specialized pump maintenance facilities at the job site.
- Multiple bearing technology for multistage high pressure pumps to ensure rotor dynamic stability and unsurpassed reliability.
- Pioneer of first high pressure vaporizer feed pumps for FSRU's with more marine and offshore high pressure pumps built than any other competitor by far.
- Specially developed ZEN™ spiral inducers to provide extremely low pumpdown characteristics.

Ongoing service from monitoringpump operating to field service and maintenance.

Nikkiso cryo now services and supplies parts for:

JC Carter

Global Network

Algeria
Australia
Austria
Belgium
Brunei
China
Egypt
France
Germany
India
Indonesia
Japan
Kuwait
Malaysia
Mexico
Netherlands
Philippines
Portugal
Qatar
Russia
S. Korea
Singapore
Spain
Taiwan
Thailand
U.A.E.
United Kingdom
United States
Vietnam

Cryogenic Industries, Inc.
27710 Jefferson Avenue, Ste. 301
Temecula, CA 92590
USA

Tel: +1.951.677.2081
Fax: +1.951.698.7484
info@cryoind.com
www.cryoind.com

Cryogenic Industries Service Companies, LLC
1851 Kaiser Avenue
Irvine, CA 92614
USA

Tel: +1.714.568.0201
Fax: +1.714.641.1921
service@NikkisoCIservice.com
www.cryoindservice.com

ACD, LLC
2321 S. Pullman Street
Santa Ana, CA 92705
USA

Tel: +1.949.261.7533
Fax: +1.949.261.6285
acd@acdllc.com
www.acdllc.com

Cosmodyne, LLC
3010 Old Ranch Parkway, Ste. 300
Seal Beach, CA 90740
USA

Tel: +1.562.795.5990
Fax: +1.562.795.5998
info@cosmodyne.com
www.cosmodyne.com

Cryoquip, LLC
25720 Jefferson Avenue
Murrieta, CA 92562
USA

Tel: +1.951.677.2060
Fax: +1.951.677.2066
sales.us@cryoquip.com
www.cryoquip.com

Nikkiso Cryo, Inc.
4705 Copper Sage Street
Las Vegas, NV 89115
USA

Tel: +1.702. 643.4900
Fax: +1.702.643.0391
info@nikkisocryo.com
www.nikkisocryo.com

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