NIKKISO

NIKKISO CRYOGENIC PUMP

SUBMERGED MOTOR CRYOGENIC PUMPS

NIKKISO CO.,LTD.

NIKKISO - *World's Leading Manufacturer of Specialty Pumps*

HISTORY OF NIKKISO CRYOGENIC PUMP

Nikkiso Co., Ltd. is a Japanese pump manufacturer with five factories, 1400 employees and net sales over $450 million. The company has half century of experience in the centrifugal pump business since 1953 of which after 1982 were specifically with submerged electric motor pumps for cryogenic liquefied gases.

Nikkiso began manufacturing cryogenic pumps in 1982 for applications in Japan and Asia. This was expanded in 1987 when they purchased sole and exclusive (but excluding USA. Canada and Mexico) rights to the cryogenic submerged electric motor pump business from J.C. Carter. At that time, all the Carter engineering, manufacturing, test, developments, and design data and procedures were transferred to Nikkiso.

Since then, Nikkiso has made substantial improvements over the original design which have been incorporated into all the pumps currently manufactured by Nikkiso.

Nikkiso constructed its Las Vegas factory and cryogenic test facility in 1997. This expansion enable pumps to be performance tested at full flow and power using LNG, LN_2, LPG, Ethane or Butane.

The affiliation with Carter was terminated in its entirely in January 2000 giving Nikkiso the right to extend it's sales rights to include the USA, Canada, and Mexico.

RELIABILITY AND LONG LIFE OF NIKKISO PUMPS ARE ASSURED BY:

Control of Bearing Loads

It is well known that lightly loaded bearings have longer lives. To achieve this, Nikkiso pumps include design features that neutralize these loads.

Radial Force Balance by Symmetrical Diffuser Geometry

Properly proportioned diffuser vanes eliminate radial loads on the bearings thus assuring long bearing life.

Radial Force Balance By Eliminating Hydraulic Instability

Flow separation from the diffuser vanes can occur at low flow rates resulting in hydraulic instability (called "rotating stall") with fluctuating radial loads on the bearings. Nikkiso eliminates these forces by careful matching of the diffuser and impeller.

Axial Force Balance

All Nikkiso pumps incorporate a balance drum mechanism that is a reliable and simple method of hydraulically nullifying all axial (thrust) loads on the bearings over the entire operating range of the pump.

Exceptional NPSH Performance

Low solidity "Fan" type inducers having high suction specific speeds provide excellent low suction pressure performance over a wide flow range. The transparency of the inducer minimizes the effect of pressure shock on the pump that occurs during pump start up or emergency valve shut down.

Safe and Reliable Electrical Connections

Dual Ceramic seal electrical penetration proven in nuclear industry has a perfect 25 year record of no leaks. Every unit is factory leak tested with helium.

Field Service

Worldwide service network with factory approved service centers in Europe, USA, and Japan.

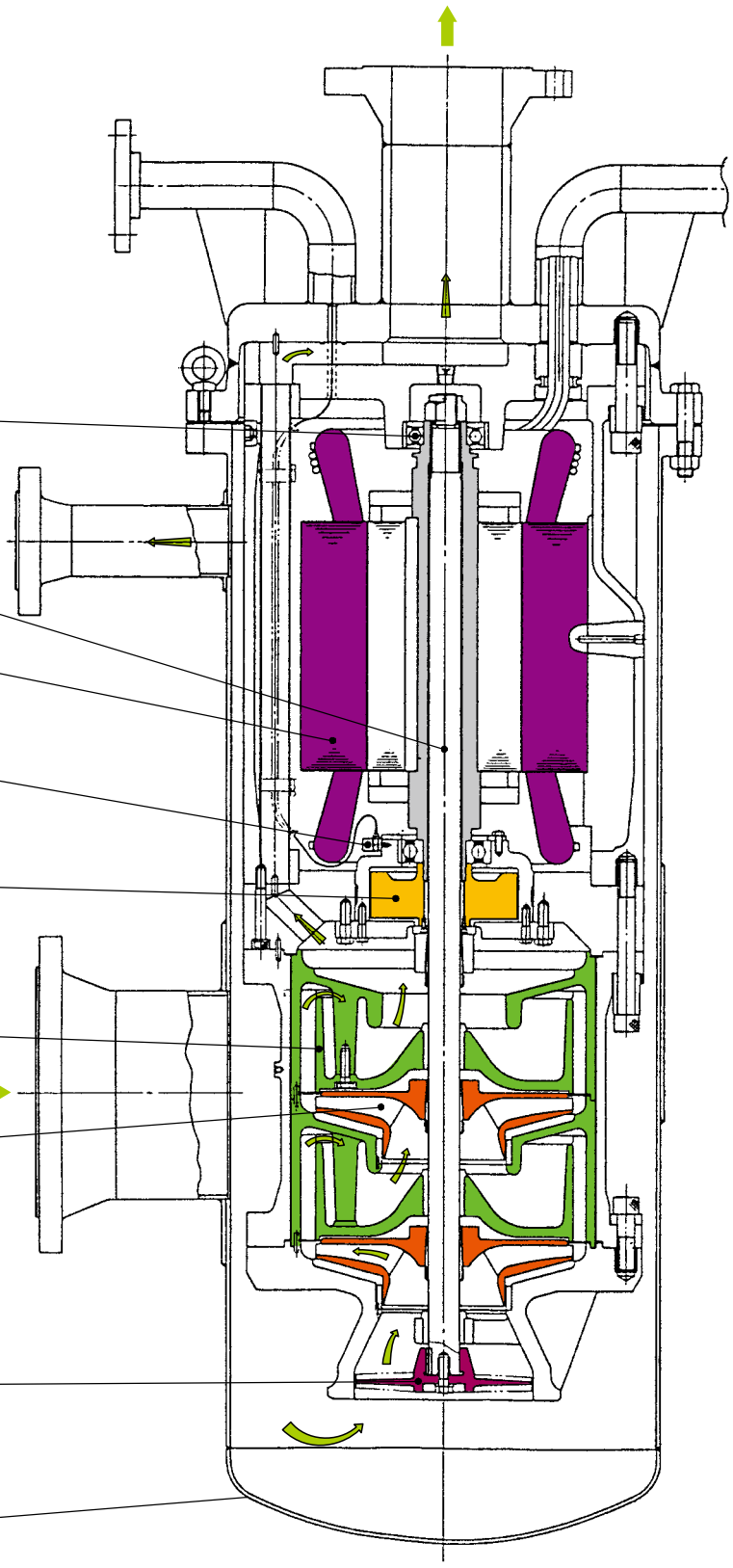
Proven Quality Assurance

ISO 9001 and 14001 certified

Design has been reviewed and approved by Lloyd's Register of Shipping, Bureau Veritas, Det Norske Veritas, Nippon Kaiji Kyokai, ABS, and U.S. Coast Guard

C O N S T R U C T I O N

SUCTION VESSEL MOUNTED



Ball bearing

Motor shaft

Cryogenic submerged motor

Accelerometer (optional)

Balance Drum

Balances thrust load over entire operating range.

Diffuser

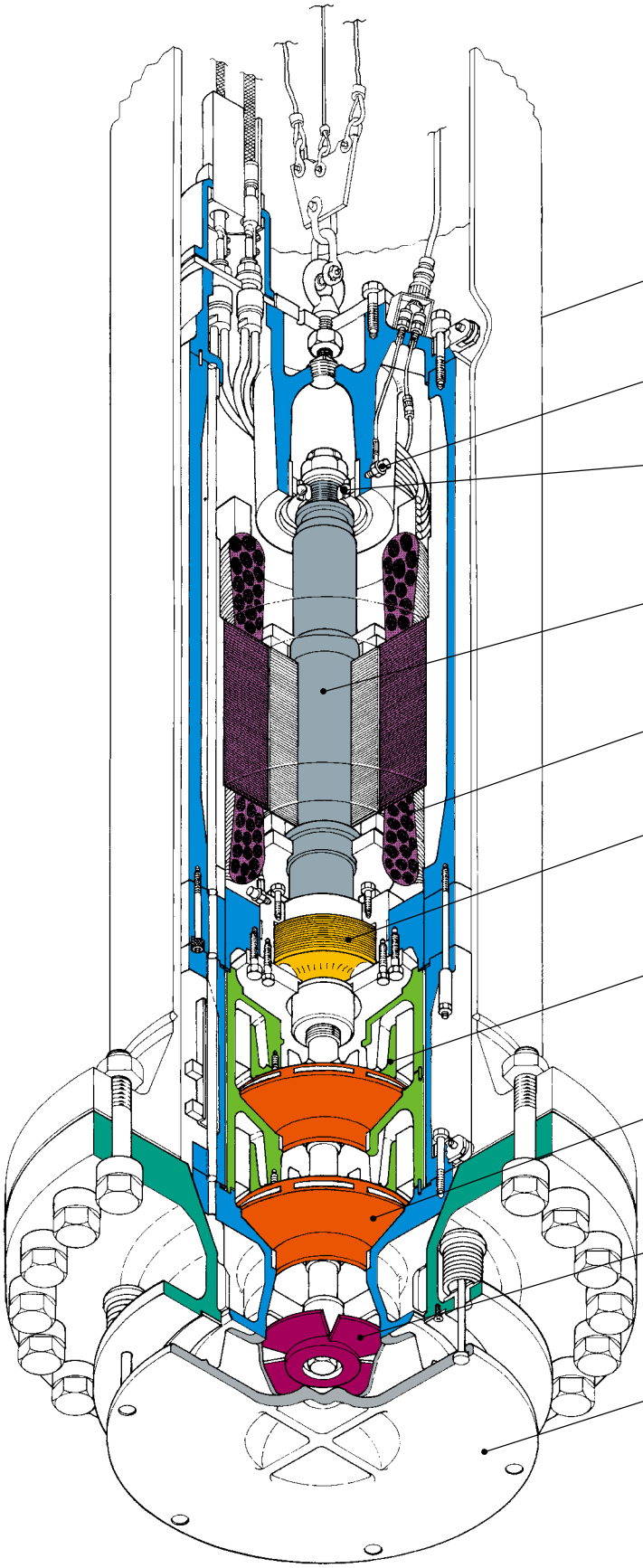
Smooth transition from Impeller to Diffuser without change in flow pattern.

Impeller

Inducer

Provides stable NPSH characteristic over a wide flow range.

Suction pot



REMOVABLE

Column

Accelerometer (optional)

Ball bearing

Motor shaft

Cryogenic submerged moter

Balance Drum

Balances thrust load over entire operating range.

Diffuser

Smooth transition from Impeller to Diffuser without change in flow pattern.

Impeller

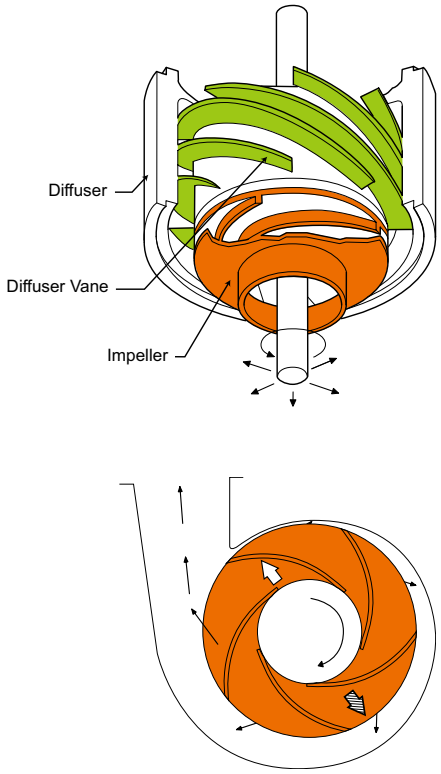
Inducer

Provides stable NPSH characteristic over a wide flow range.

Foot valve

DESIGN & RELIABILITY FEATURES

Balance - *the key to longevity and reliability*

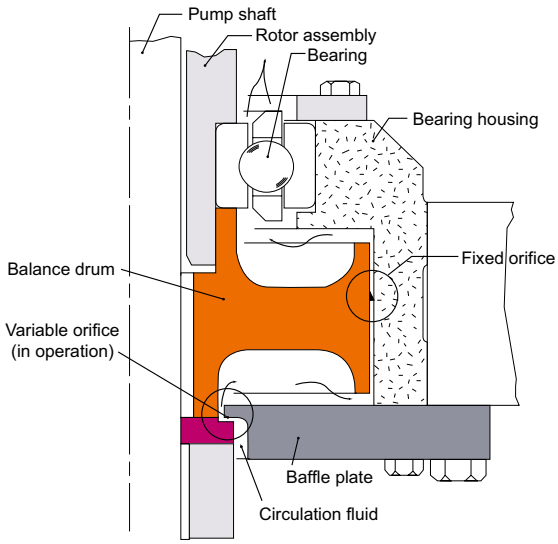


RADIAL BALANCE

Imbalance of radial forces reduces bearing life. NIKKISO CRYOGENIC pumps eliminate both hydraulic and mechanical imbalance. In NIKKISO CRYOGENIC pumps the diffuser is symmetrical with the fluid which exits the impeller being received by the axial diffuser with perfect hydraulic symmetry at all flow conditions. In contrast, conventional pumps depend on an asymmetrical scroll diffuser which has variable radial loads with different flow conditions. In the case of conventional volute casing pumps, the radial reaction force working on the impeller is theoretically zero at the design flow point. During an off-design high or low flow, however, an out-of-balance condition develops in the pressure distribution inside the volute, producing a radial reaction force. The mechanical balance is assured by symmetry and exacting dynamic balancing at the factory.

AXIAL THRUST BALANCE

NIKKISO CRYOGENIC pumps utilize an automatic axial thrust balancing mechanism which equalies pressures to produce zero net thrust from the rotating element. This is accomplished with a variable axial throttle which controls the pressure on the balance drum. Increasing discharge pressure is utilized to increase the counteracting force below the balance drum. During performance testing of NIKKISO CRYOGENIC pumps, axial thrust forces are measured to assure no load is being taken by the bearings.

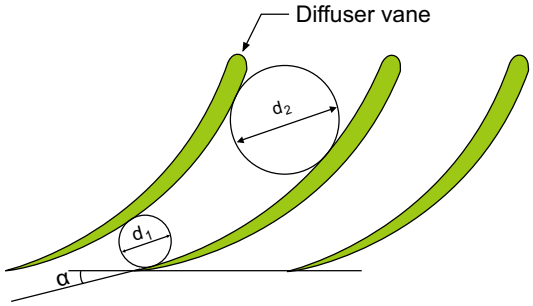


IN OPERATION

EFFICIENCY

The key element in pump efficiency is the fluid dynamics of accelerating the fluid in the impeller passages and recovery of pressure in the diffuser. Although the impeller is rotating, the impeller hydraulics are symmetrical and the fluid flows smoothly through the impeller passages. The diffuser must receive the fluid in a smooth transition with a minimum of discontinuity and turbulence. NIKKISO CRYOGENIC pumps use axial vane diffusers which provide symmetry and smooth transitions. The symmetry eliminates radial thrust. The radial axial flow transition minimizes the shear between the impeller discharge and the discharged fluid at all flow rates.

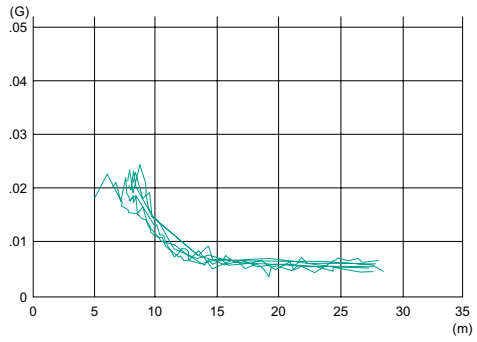
OPTIMUM DESIGN OF AXIAL VANE DIFFUSER

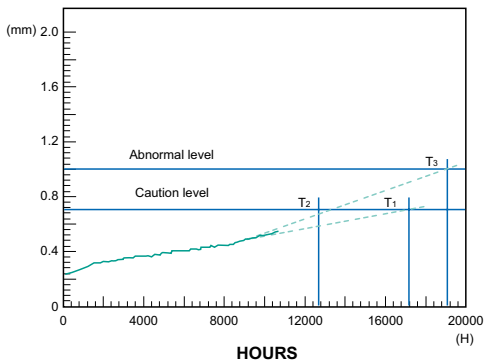


Diffusers with high fluid efficiency can be designed by optimizing the design parameters, such as the vane angle (α), the diffuser inlet area (d1), and the diffuser area ratio (d2/d1).

CONDITION MONITORING

Pump vibration is an excellent means to monitor pump condition and operation. Piezoelectric detectors measure accelerations directly and, with signal conditioning, provide velocity and displacement amplitude data. This sensor is small and can be installed inside the pump, directly mounted on the bearing housings. Conditions of internal parts and the extent of wear are determined by trend monitoring and frequency analysis. Eddy Current Displacement gauges measure axial pump shaft vibration. Two cells oriented at 90 degrees monitor bearing wear and shaft motion under both stable and severe operating conditions during starting or stopping. Data can be used to improve operations and extend pump life.



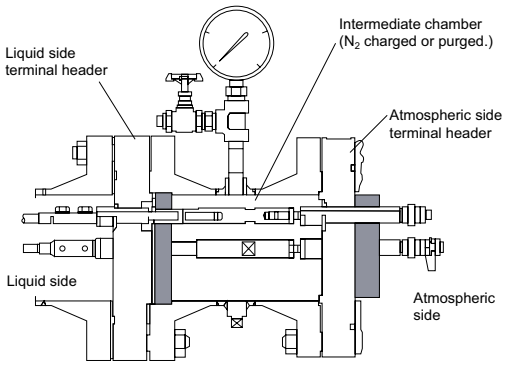


As a result of NIKKISO's research and development and through NIKKISO's service organization, operating personnel can be trained to interpret the data acquired from condition monitoring. NIKKISO research has correlated monitoring specific vibration modes with specific operating and wear conditions. Condition 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, operations and costs. Condition monitoring permits scheduling maintenance only when essential and indicates the need for immediate maintenance to prevent outage. Ultimately, this unique service saves money through longer, more efficient pump life and strategically planned maintenance.

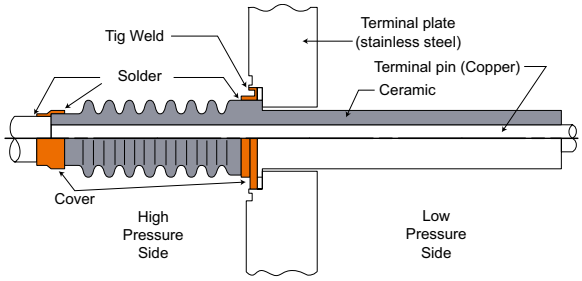
CERAMIC SEAL TERMINAL HEADER

DOUBLE SAFETY CONSTRUCTION: A key safety feature for submerged motor pumps is the sealing of the electrical connections. The electrical terminal header is designed to withstand high pressure and electrical surges. NIKKISO CRYOGENIC Pumps use a ceramic gas seal terminal and dual header seal which ensures the highest reliability.

FEATURES INCLUDE: All seals are either welded or soldered using special welding techniques NIKKISO developed for canned motor pumps. The ceramic gas seal was developed by NIKKISO for nuclear pumps. The ceramic gas seal has an excellent record of extended leak free operation. The gas seal header uses two terminals installed in series with an intermediate chamber charged with N_2 gas. A leak of either seal will not allow gas to pass through the header. By setting the N_2 charge pressure below the pump pressure but above atmospheric pressure, leakage of either seal is readily detected.



DUAL TERMINAL HEADER



CERAMIC GAS SEALING TERMINAL

CONSTRUCTION AND MAINTENANCE

With the user in mind NIKKISO has designed the pumps for simplicity, low weight and easy assembly. Aluminium alloy is used for the casing, impeller and other parts. Lightweight easy-to-handle aluminium alloy contributes significantly to facilitating maintenance work.

Because of the simplicity of the construction and a minimum number of parts, disassembly and reassembly can be done in a short time. The features include a stepless pump shaft, colleted impeller free of keys and bolts, and monolithic diffuser (casting assembly consisting of sleeve bearing and the casing).

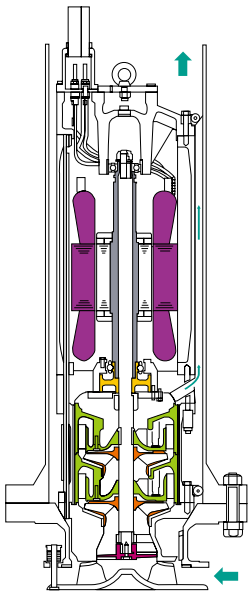
COOL-DOWN and WARM-UP TIME

Before operating the pump, the entire pump must be cooled down. Because of its smaller heat capacity, aluminium alloy shortens the time required for cool-down or warm-up, thereby making the maintenance work more efficient. Cool down liquid losses are also reduced.

SERVICE ORGANIZATION

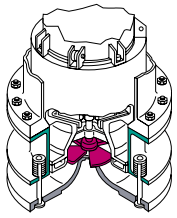
Nikkiso has a worldwide service network with factory approved service centers in Europe, USA, and Japan.
Service in Asia and India is provided through a Nikkiso subsidiary company “Nikkiso Ryuki Techno Co.” with full time engineers based at Nikkiso’s Higashimurayama (Tokyo) plant where close contact is maintained with the primary design engineering and manufacturing staff. Service in USA and South America is provided through Nikkiso Cryo, Inc. based in Las Vegas, Nevada, USA which is a full design, manufacturing, and test facility staffed with engineers as well as assembly and test technicians while service in Europe, Africa, and the Middle East is provided through Nikkiso Cryo. Europe based in London, UK.

INSTALLATION OPTIONS

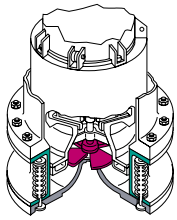


REMOVABLE

Removable pumps offer the advantage of overhead withdrawal plus replacement without taking the tank out of service. The pump operates at the bottom of the column through which it is installed and removed. The column provides the fluid discharge and electrical connections.
The pump is seated on a conical seated foot valve adapter at the bottom of the column. The weight of the pump opens the spring loaded foot valve. When the weight of the pump is removed, the foot valve closes. The additional advantages of this type of installation include less external piping and no penetrations below the tank liquid level.



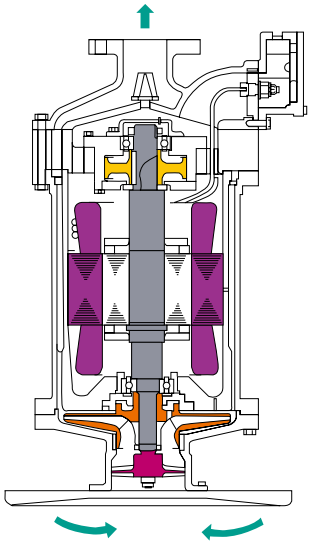
FOOT VALVE OPEN

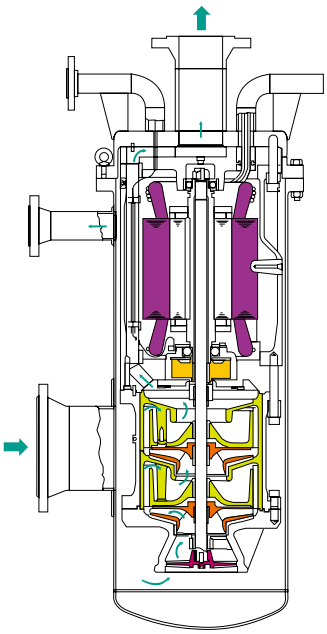


FOOT VALVE CLOSED

FIXED CARGO

The Fixed Cargo type of pump is used on liquefied gas carriers and is mounted on the bottom of the cargo tank or is suspended by the discharge pipe inside the cargo tank. This approach allows liquid overhead withdrawal where bottom tank penetrations are not feasible or desired. These pumps are used mainly for cargo unloading. This approach is designed to withstand tough cargo pump service with simplicity and minimum cost.





SUCTION VESSEL MOUNTED

Suction Vessel Mounted pumps are an integral part of the piping typically mounted between piping flanges with external suction and discharge connections. The pump is mounted on a blind flange such that primary pressure barriers between the fluid product and outside environment are totally contained within the pressure vessel. Shaft seals are eliminated. The pump inlet is below the suction vessel inlet which allows source tank liquid levels to be lowered to a minimum. The suction vessel may also serve to remove entrained vapors. 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.

PUMP SELECTION

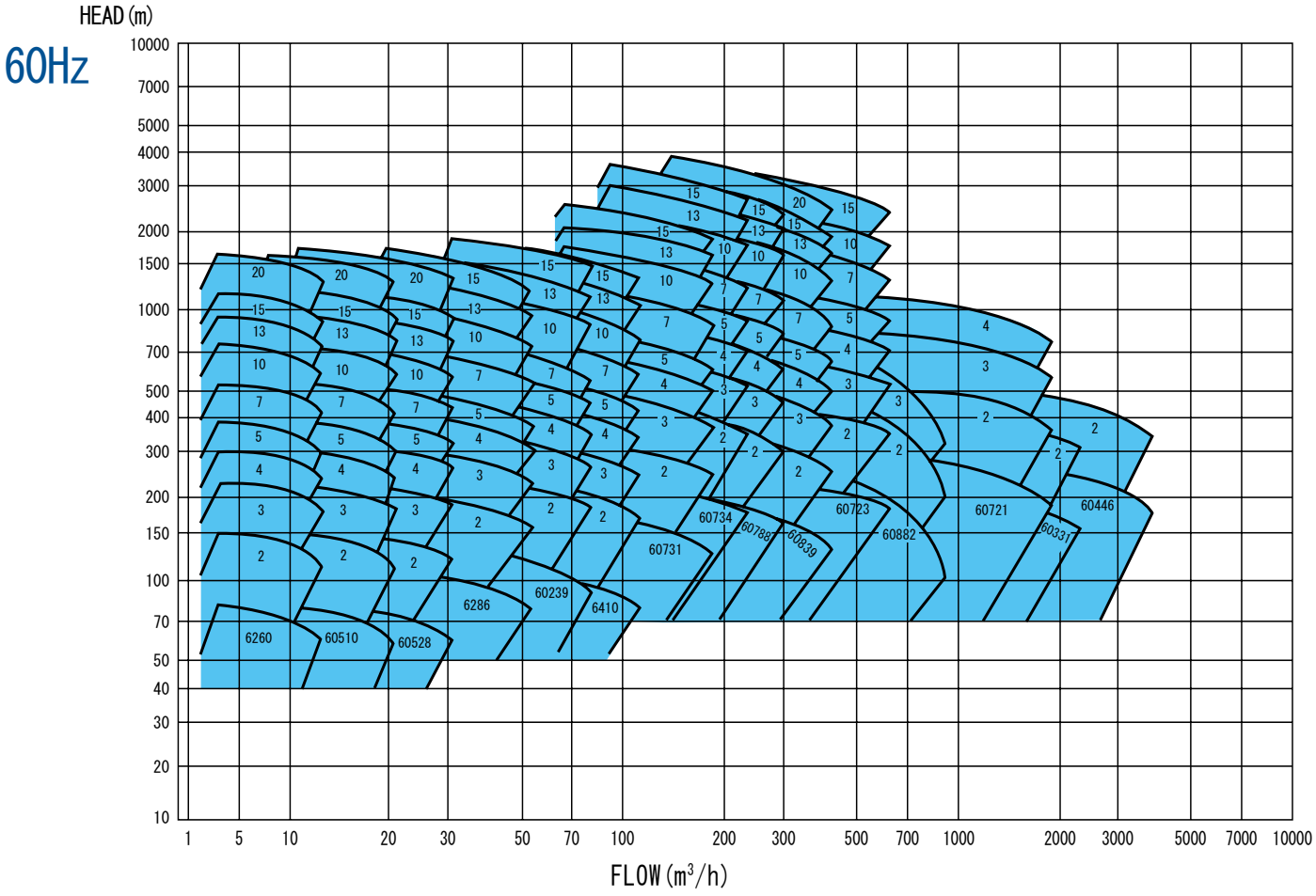
NIKKISO will select pump components to meet all combinations of flow and pressure conditions. Optimum pump capacities are accomplished by selecting high efficiency impellers for flow rates and selecting the number of stages to meet pressure requirements.

Pump Model Designations are:

MODEL INDICATION: ○○○○○ L ○ — △ ○○○ X

- ○○○○○ — PUMP DESIGN NO.
- ○ — NUMBER OF STAGES
- △ — TYPE: R: REMOVABLE, P: POT, F: FIXED
- ○○○ — MOTOR kW
- X — MOTOR WINDING CONSTRUCTION: F: FORMED, R: RANDOM

TYPICAL PERFORMANCE OF NIKKISO-CRYOGENIC PUMPS



MOTOR SELECTION - FEATURES AND OPTIONS

Type:	Submerged, 3 -phase induction motor	**Windings:**	Formed wound/random wound.
Frequency:	50/60Hz	**Insulation:**	Vacuum pressure impregnation using special cryogenic varnish, class F.
Voltage:	200/400/3000/3300/6000/6600V, etc.		
No. of Poles:	2/4	**Starting:**	Full voltage start (standard)
Time Rating:	Continuous		Optional Reduced voltage VFD

TESTING

Nikkiso has the ability to perform cryogenic pump testing at either of its two test facilities depeding on the fluid being pumped. The Higashimurayama facility can test with LN_2 whereas the Las Vegas facility can perform tests on LN_2, LNG, and LPG. Full flow and power tests can be conducted at full or variable speeds and with voltages up to 6,600 volts. Full instrumentation permits performance and NPSH tests to be conducted and pump condition can be determined with vibration and shaft lift monitoring.

NIKKISO CO.,LTD.

Cryogenic Pump Department: 2-16-2, Noguchi-cho, Higashimurayama, Tokyo 189-8520, Japan

Telephone: +81-42-392-3548 Facsimile: +81-42-392-3549

Factories: Tokyo, Shizuoka, Kanazawa, Japan International: Germany, China, Singapore

NIKKISO CRYO, INC.

4661 Eaker Street, Las Vegas, NV 89031, U.S.A.

Tel: +1-702-643-4900 Fax: +1-702-643-0391

LEWA GmbH

Nikkiso Cryo Department: Ulmer Straβe 10, 71229 Leonberg, Germany

Tel: +49-7152-14-0 Fax: +49-7152-14-1303

Catalog No.2079 March,2011