



Specialist for Pumping Technology

Session 24 – Cryogenic Pumps

Simon Smith June 2023



Presenter Profile – Simon Smith

Simon graduated with an honours degree in Chemical Engineering from the University of Surrey in 1978 and began a long career in the engineered pump industry spanning 40 years (so far!) with Peerless Pump, BW/IP International / Flowserve, SPP Pumps, Ruhrpumpen and Ebara Cryodynamics.

Over his long career he has filled various roles as Applications Engineer / Manager, Project Manager, Key Account Specialist, Vertical Pump Product Specialist, International Sales Engineer / Manager / Director and he has considerable experience in Training & Mentoring young engineers.



Ruhr*RP*umpen Short Courses

Here is a listing of all the previous courses.

- No 1 – API610 12th v 11th editions
- No 2 - Curve Shape
- No 3 – The Importance of System Curves
- No 4 - Selecting the Right Pump for the Application
- No 5 - NPSH & Nss
- No 6 - Mechanical Seals & Systems
- No 7 - Firepumps
- No 8 - BB5 Barrel Pumps
- No 9 - Pump Instrumentation
- No 10 – Non-Destructive Examination
- No 11 - Vertical Pumps (Part 1) Type VS1, VS2, VS3
- No 12 – Vertical Pumps (Part 2) Type VS4, VS5, VS6 & VS7
- No 13 – Performance Testing of Centrifugal Pumps; the What, the Why & the How
- No 14 – Testing & Inspection of API 610 Pumps
- No 15 – Start-Up, Commissioning & Troubleshooting Centrifugal Pumps
- No 16 – Introduction to Positive Displacement (Plunger) Pumps
- No 17 – Refresher Session
- No 18 – Overhung Process Pumps OH1 & OH2
- No 19 – Vertical Overhung Process Pumps OH3-OH6
- No 20 – New Developments in the VS6 Market
- No 21 – BB4 Multistage Pumps for the Power Industry
- No 22 – Coking Process and Hydraulic Decoking Equipment
- No 23 – Pumps for the Desalination Market

Any you have missed you can get from our website using this link <https://short-courses.ruhrpumpen.com/>

Or from www.ruhrpumpen.com and follow the link to [RP Short Courses](#)



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Pumps for
Oil and Gas

The most reliable and efficient
pumps with cutting-edge technology
according to API standards

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The most efficient and reliable pump systems worldwide

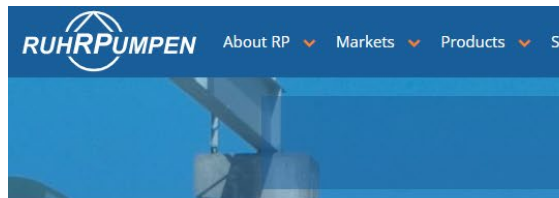
Ruhrpumpen is an innovative and efficient pump technology company that offers highly-engineered and standard pumping solutions for the oil & gas, power generation, industrial, chemical and water markets. We offer a broad range of centrifugal and reciprocating pumps that meet and exceed the requirements of the most demanding quality specifications and industry standards such as API, ANSI, ISO and Hydraulic Institute.

[+ About Ruhrpumpen](#) [+ Our Pumps](#)



RuhRPumpen Short Courses

<https://short-courses.ruhrpumpen.com/>



More Articles

- Impeller Lift Procedure
- Newsletter Ruhrpumpen Fire Systems - December 2022
- CPP Process Pump Line New Sizes
- All Courses
- Ruhrpumpen Resources
- Hayward Tyler Signs Agreement with Ruhrpumpen to Service Vertical & Industrial Pumps.
- RP achieves ISO 9001:2015 for its industrial pump unit
- Ruhrpumpen CPO pump range for industrial processes
- Packing strips and packing gland tightening procedure
- New life to old vertical pump

**QUALITY
INNOVATION
EFFICIENCY**

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Welcome to Ruhrpumpen's Media Center

Here you'll find our latest corporate news, product updates and articles from our experts in pumping

SHORT COURSE 3

The Importance of Using System Curves in Pump Selection and Successful Pump Operation

Full session.

Downloads.

SHORT COURSE 4

Selecting the Right Pump

Full session.

Downloads.

SHORT COURSE 5

NPSH Made Simple

Full session.

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SHORT COURSE 6

Mechanical Seal Selection

Full session.

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SHORT COURSE 7

Fire Pumps for the Oil & Gas Industries.

Full session.

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SHORT COURSE 8

Double Case Pumps (Barrel Pumps - BB5).

Full session.

Downloads.

SHORT COURSE 9

Understanding pump instrumentation.

Full session.

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SHORT COURSE 10

Non-Destructive Examination (NDE).

Full session.

Downloads.



RuhRPumpen Short Courses

Session 24 – Cryogenic Pumps

This short course will look at Cryogenic Pumps used in Liquid Oxygen, Liquid Nitrogen and LNG / LPG Services.

Aimed at Process and Mechanical Engineers and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.

- Ruhrpumpen has more than 45 years of successful installations at Air Liquide, Air Products, Linde and other reputable End Users
- We are able to offer Cryogenic pumps utilizing hydraulics from our vertical pump (VS6) and (OH3) pump ranges
- Cryogenic Pump (design modification from standard API pump) typically required for:
 - Temperatures below -73C for VS6 configuration
 - Temperatures below -50C for OH3 configuration

Liquid Oxygen (LOX)

Typically at -290 F (-178.9C) ,
Specific Gravity 1.14

Liquid Nitrogen (LIN)

Typically at -320 F (-195.6C),
Specific Gravity 0.808

Hydrocarbons & LNG Services

Propane, - 45 F (-42.8C) Specific Gravity
0.585 (standard pump design)

Methane, -249 F (-156.1C), Specific Gravity
0.717

Argon, -302 F (-185.6C) Specific Gravity 1.62



Vertical OH3 Pumps

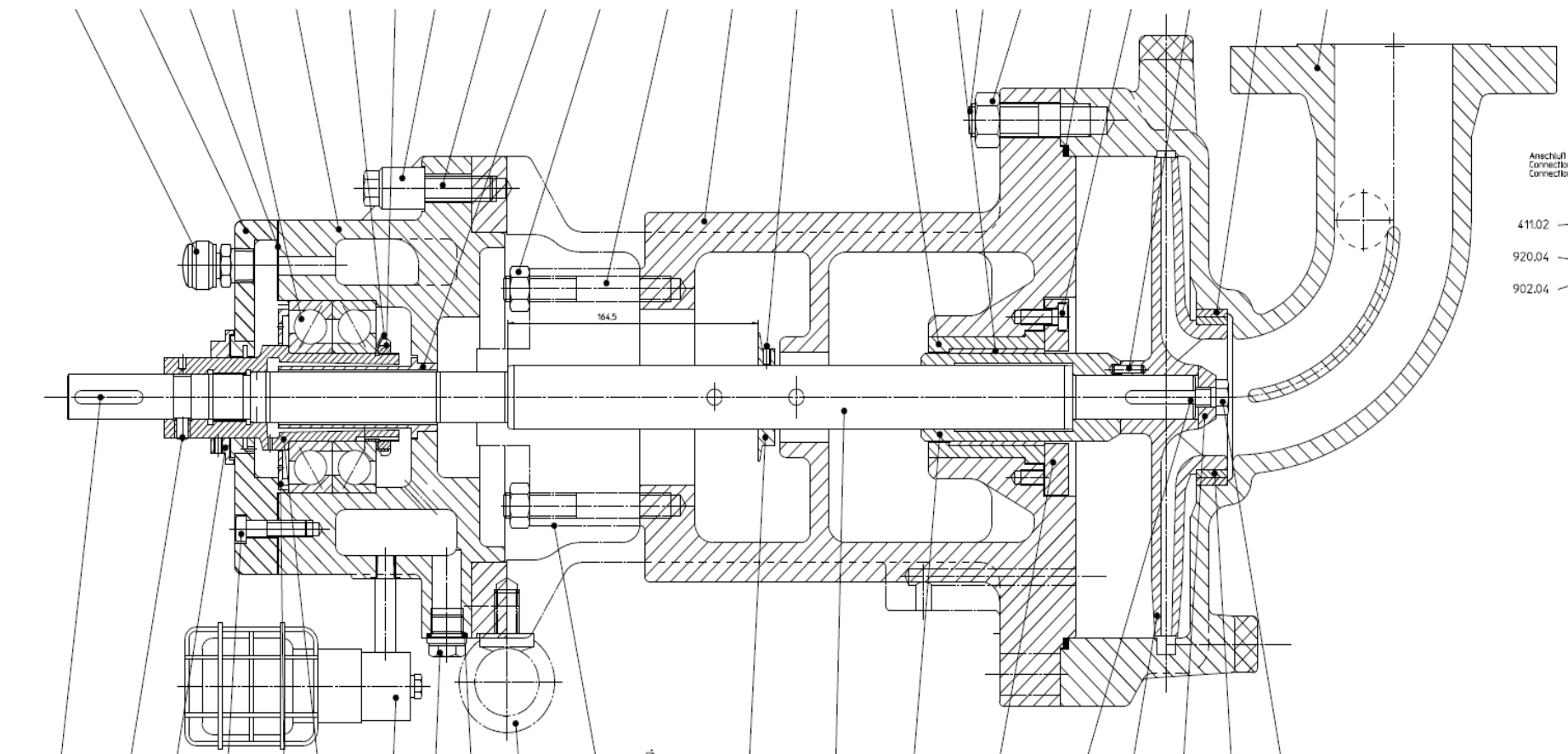
- Utilizes Ruhrpumpen OH2 pump hydraulic mounted vertically (OH3)
- This design is normally required for products with pumping temperature below -50C
- Casings are vertically mounted with side/side nozzles
 - The radially split casing provides effective joint sealing of cryogenic and low density process fluids.
- The cover includes the warmup chamber which ensure that the mechanical seal chamber sees ambient temperature fluid and thus prevents the mechanical seal from icing

- Bearings
 - Axial thrust flood oiled double angular ball bearings with Trico oilers are standard.
 - Radial bearing is a hydrodynamic bearing located directly behind the impeller hub. The hydrodynamic bearing is medium lubricated.

- Heavy duty Mounting Frame
 - They are fabricated from carbon steel according to Ruhrpumpen standard procedures with a drain pan and flanged drain connection.
 - The underside of all baseplates are prepared for epoxy grout as standard.

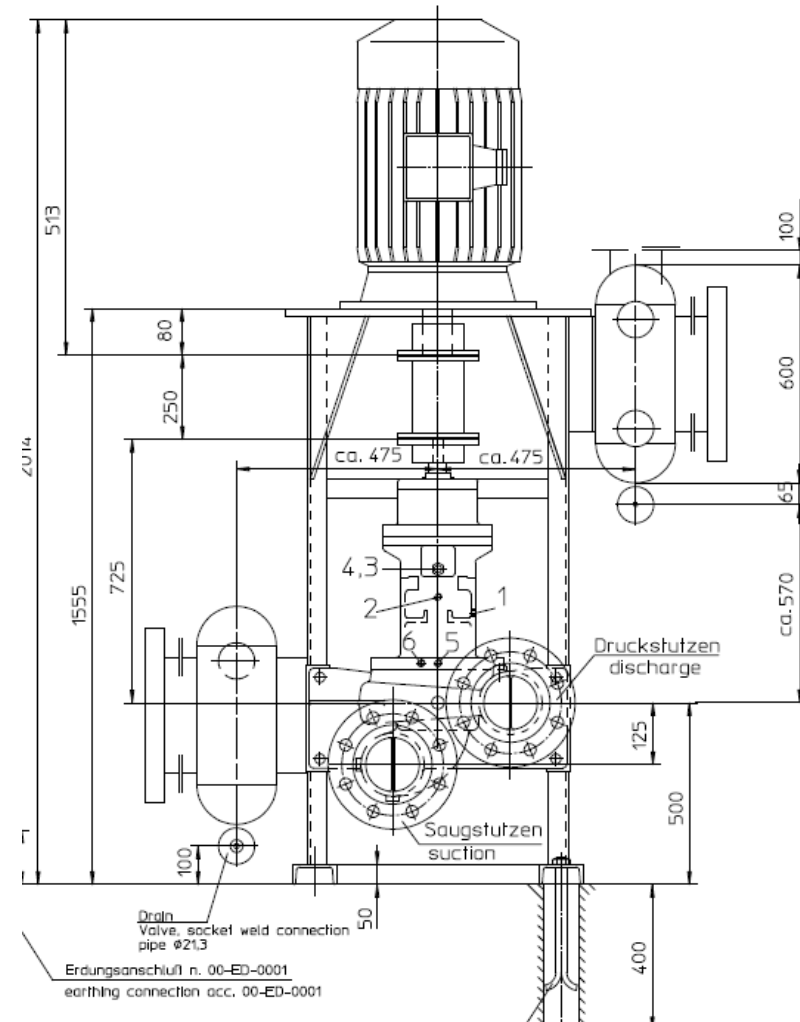
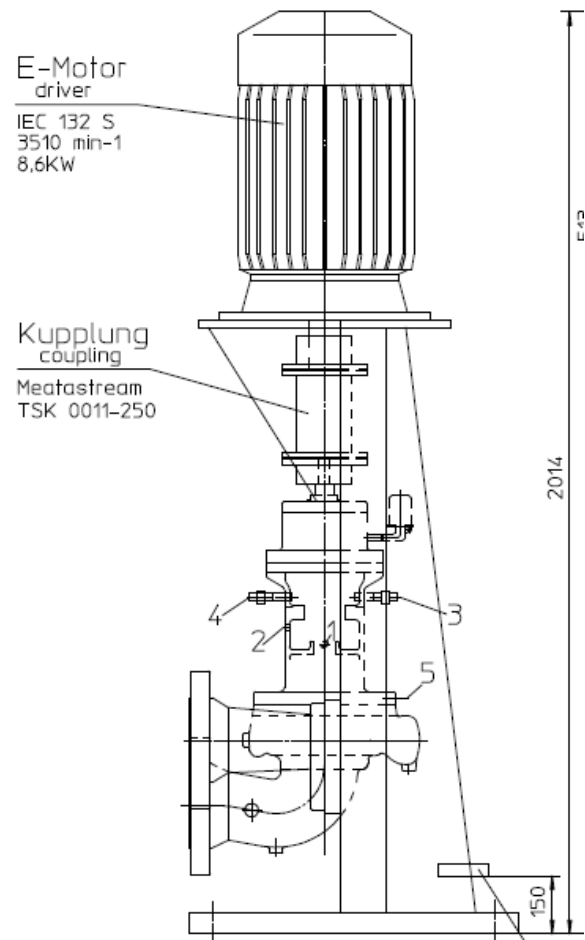


SVNV





SVNV



Vertically Mounted OH3 Cryogenic Pump



horizontal, single stage,
single flow, radial split
process pump, type SVN 2x12
for a refinery.

design according API 610.

operating data

fluid	hydrocarbons
capacity	69 m ³ /h
head	105 m
temperature	-108 °C
motor power	30 kW
speed	2960 1/min

Process Pump Type SVN



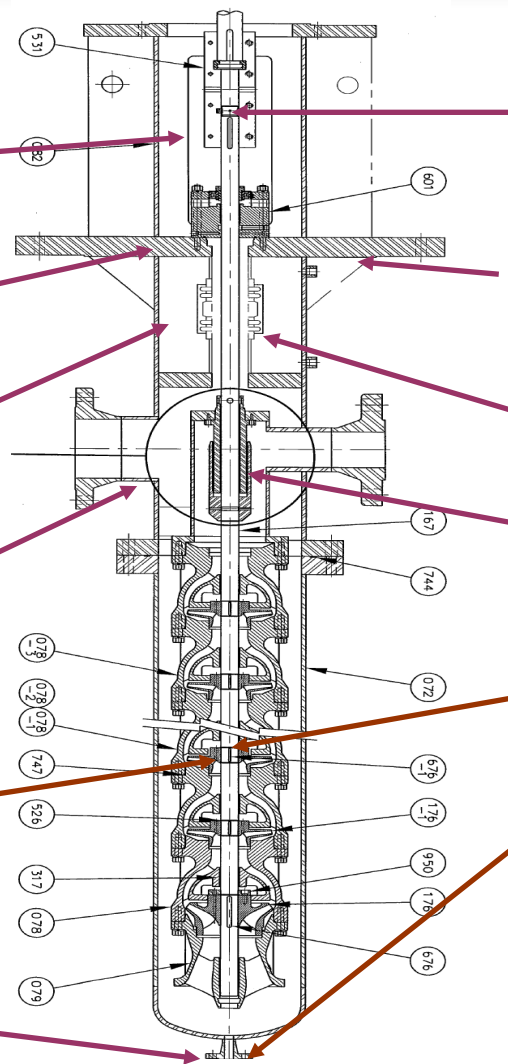
VERTICAL MULTISTAGE PUMPS (VS6)



CRYOGENIC VLT - EXAMPLE

Features:

1. Axially Split Coupling
2. Mounting plate option
Can also be place below the nozzles if required
3. Expansion Chamber
4. Throttle Bushing breaks down discharge pressure
5. DUB Bearings
6. External Drain (if required by customer)



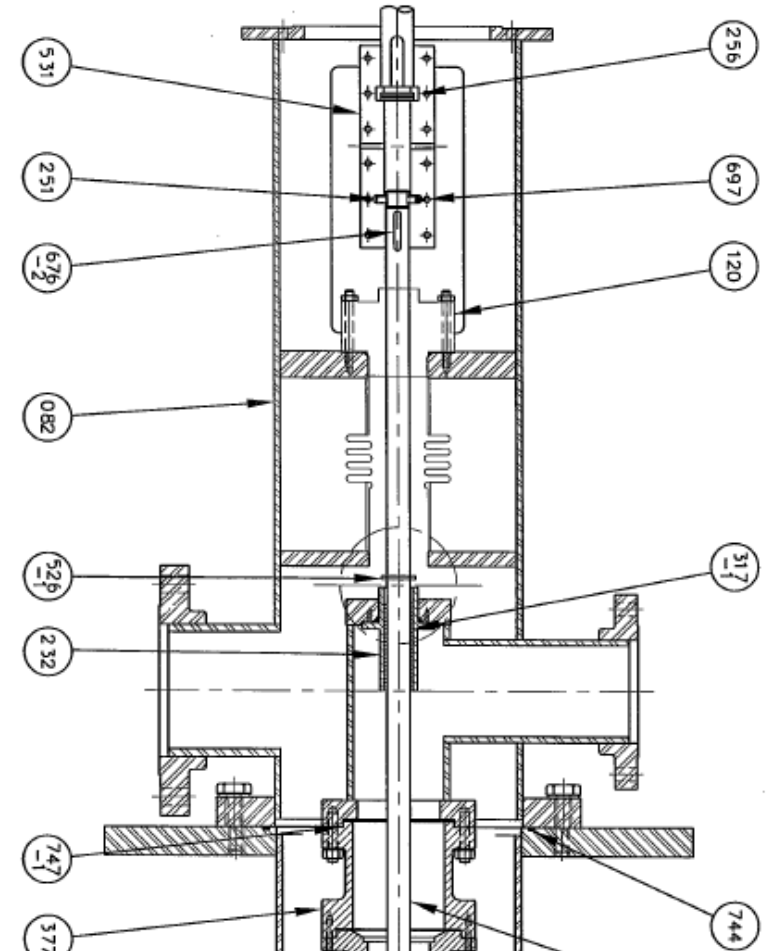
Benefits:

1. Designed to permit seal removal without removing driver
2. Pump can be mounted on Cold Box - no cool-down time required between starts
3. Ensures warming of the liquid so that only Gas enters the stuffing box.
4. Provides suction pressure at the inlet to the warmup chamber.
5. Bronze back teflon (DUB) Bearings that are self lube and can run dry for short times.
6. Ensures Efficient drainage of the Cryogenic Liquid without external purge.



WARMUP CHAMBER

- As the liquid moves up the inner column in the warmup chamber the temperature of the liquid increases above the critical temperature and it changes to a gas.
- Hence gas at close to ambient temperature is delivered to the seal chamber and therefore conventional mechanical seals, gaskets and elastomers can be utilized.
- No external heating source required.



EFFECTIVENESS OF WARM-UP CHAMBER

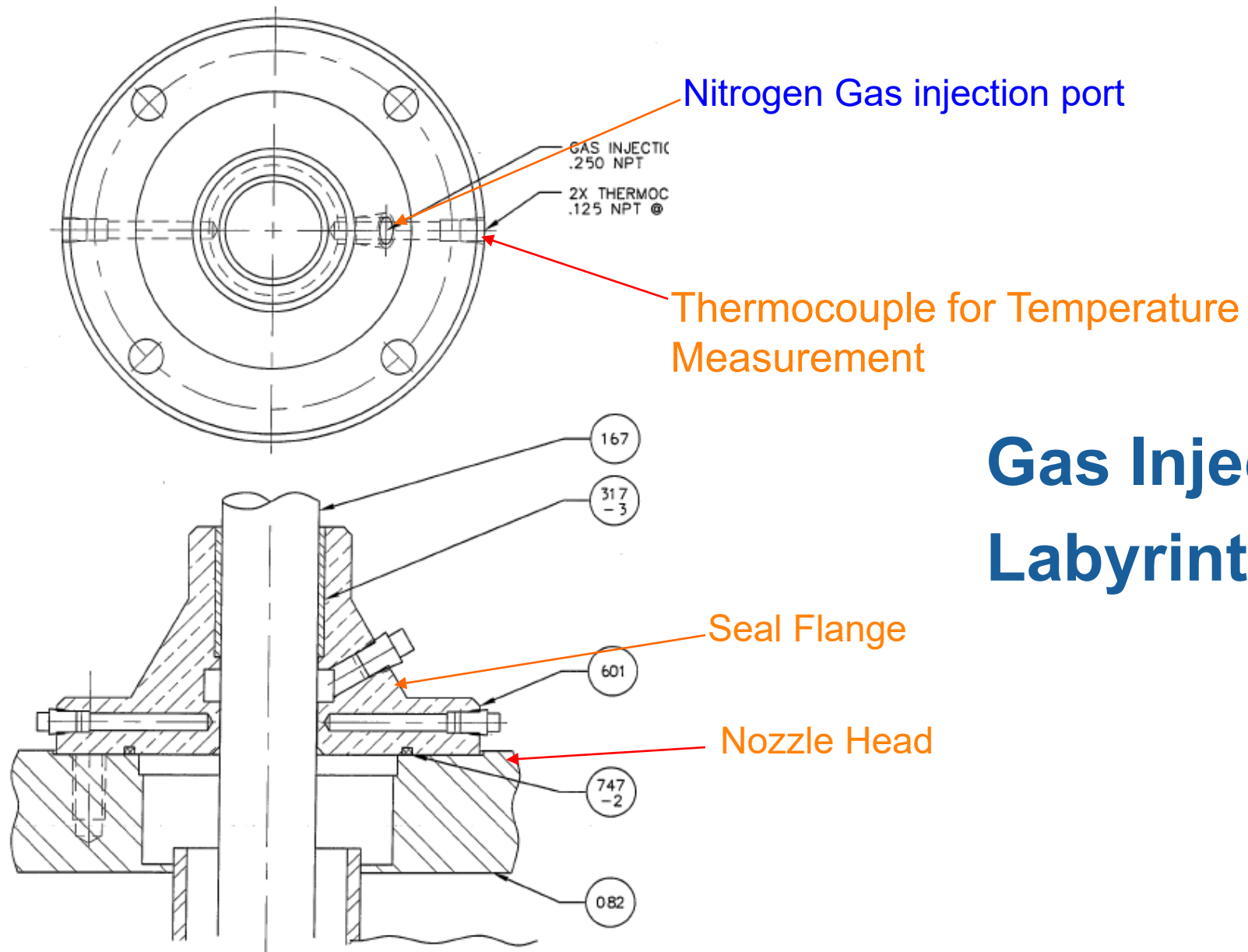


TYPICAL MATERIALS

Part	Liquid Oxygen	Liquid Nitrogen	Hydrocarbons
Nozzle Head	304 SS	304 SS	304 SS
Suction Barrel	304 SS	304 SS	304 SS
Series Case (Bowls)	70-30 Cupro Nickel	70-30 Cupro Nickel	316 SS
Impellers	Bronze	Bronze	304 SS
Shaft	K500 Monel / Nitronic 50	K500 Monel / Nitronic 50	Nitronics 50
Radial Bearings	DUB (Teflon Coated)	DUB (Teflon Coated)	Carbon w/ Nickel Binder
Throttle Bushing	High Lead Bronze	High Lead Bronze	Carbon w/ Nickel Binder
Barrel Gasket	304L SS Winding w/ Graphite	304L SS Winding w/ Graphite	304L SS Winding w/ Graphite
Bolting	K500 Monel / Nitronic 50	K500 Monel / Nitronic 50	316 SS
Retaining Rings	Monel	Monel	Monel

1. Gas Injection Seal Flange (Labyrinth type – Ruhrpumpen own design)

- Used for Liquid Nitrogen & Liquid Oxygen Service
 - Nitrogen gas is injected at 5-10 psi above suction pressure through a Labyrinth Flange installed in the nozzle head just below the coupling
 - The pumped fluid below the flange is in gaseous state
 - The injected Nitrogen warms up the product prior to exiting
 - An RTD Connection is provided at the Seal Flange to monitor effectiveness of this Flange
 - Reduction in Temperature indicates lack of Nitrogen being injected or that the Throttle Bushing is worn out



Gas Injection Labyrinth Seal

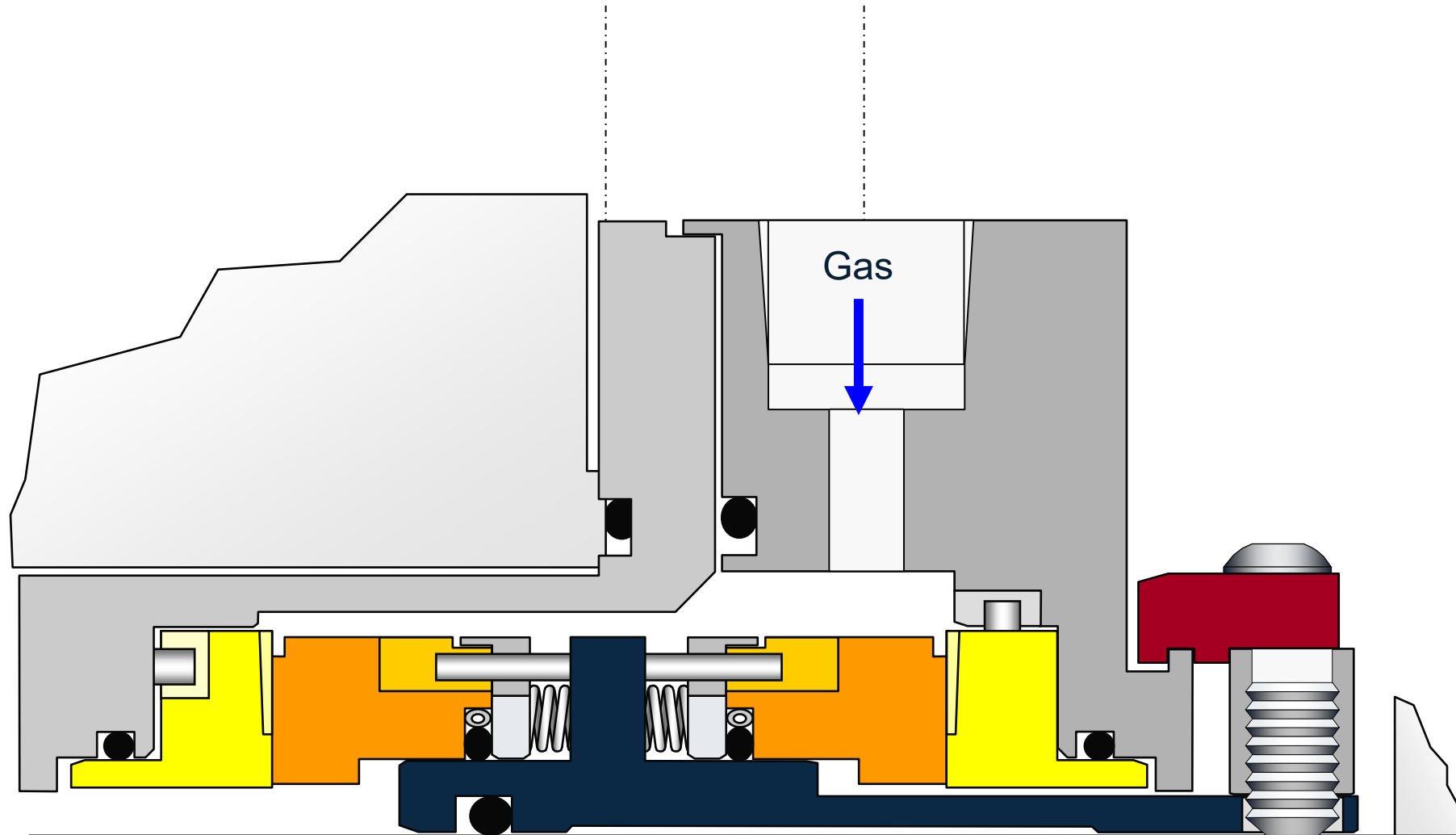
2. Single Mechanical Gas Seal

- Used for Liquid Nitrogen & Liquid Oxygen Service
- Typically dry gas seal type with external nitrogen purge to dissipate any small leakages
- Seals will only see suction pressures and should be suitable for 10F

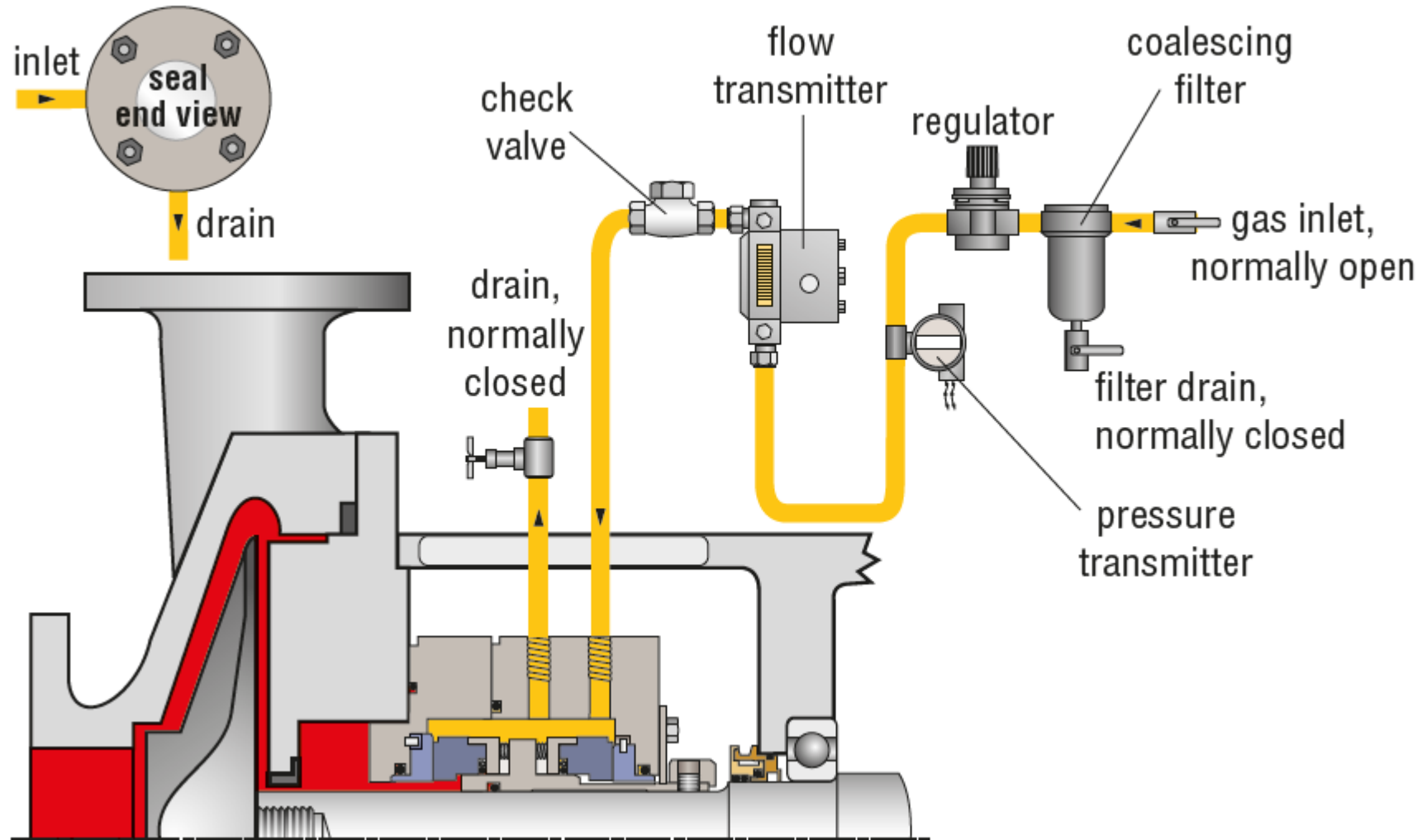
3. Double Mechanical Gas Seal

- Used for Methane, Ethylene & Propane services
- Typical Arrangement includes injection of a dry inert gas (nitrogen, usually) between the two seals via a Gas Regulating Panel (Plan 74) that ensures supply pressure at 25 psi above suction pressure
- RTD Connection Provided below the seal to monitor temperature

Typical Dual Gas Seal for Cryogenic Service



Gas Injection Seal Plan 74

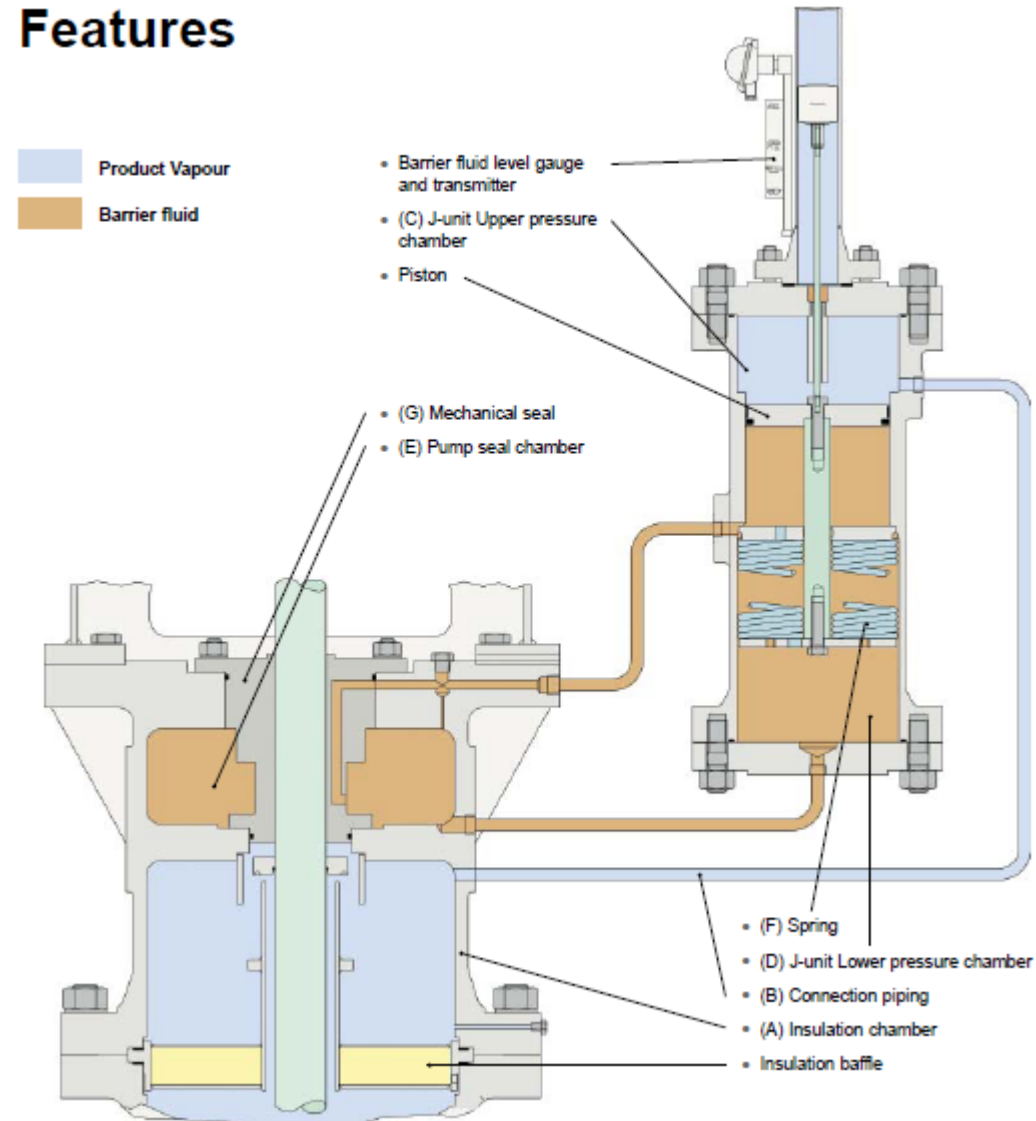


4. Double (Dual Pressurised) Mechanical Wet Seal

- Used for Methane & Ethylene
 - Not so often used in cryogenic pumps because leakage past the primary seals from the buffer side can contaminate the pumped fluid. But it is preferred by some customers and RP has some design solutions to mitigate this concern.
 - Typical System Consists of Dual Seals with External Buffer Fluid Injection between the two Seals
 - RTD Connection Provided below the seal to monitor temperature

Sulzer J-Unit Cryogenic Sealing System

Features





Sulzer J-Unit Cryogenic Sealing System

Principal of Operation

The insulation chamber (A) provides a thermal barrier between the mechanical shaft seal and the pumpage. Piping (B) from the top of the insulation chamber transmits suction pressure to the upper portion of the J-unit (C), forcing the piston down. This action pressurizes the sealing fluid in the lower portion of the pressure chamber (D).

The resultant pressure transmitted to the seal chamber (E) is equal to the suction pressure PLUS the load of the spring (F) acting on the piston.

This pressure differential between the insulation chamber and the seal chamber prevents the pumpage from contaminating the seal faces or escaping to atmosphere and provides the ideal operating environment for the mechanical seal faces with regard to temperature, pressure and lubrication.

To facilitate cooling, the sealing fluid is continuously circulated between the seal chamber and the pressure unit via a pumping ring fitted to the mechanical seal (G).

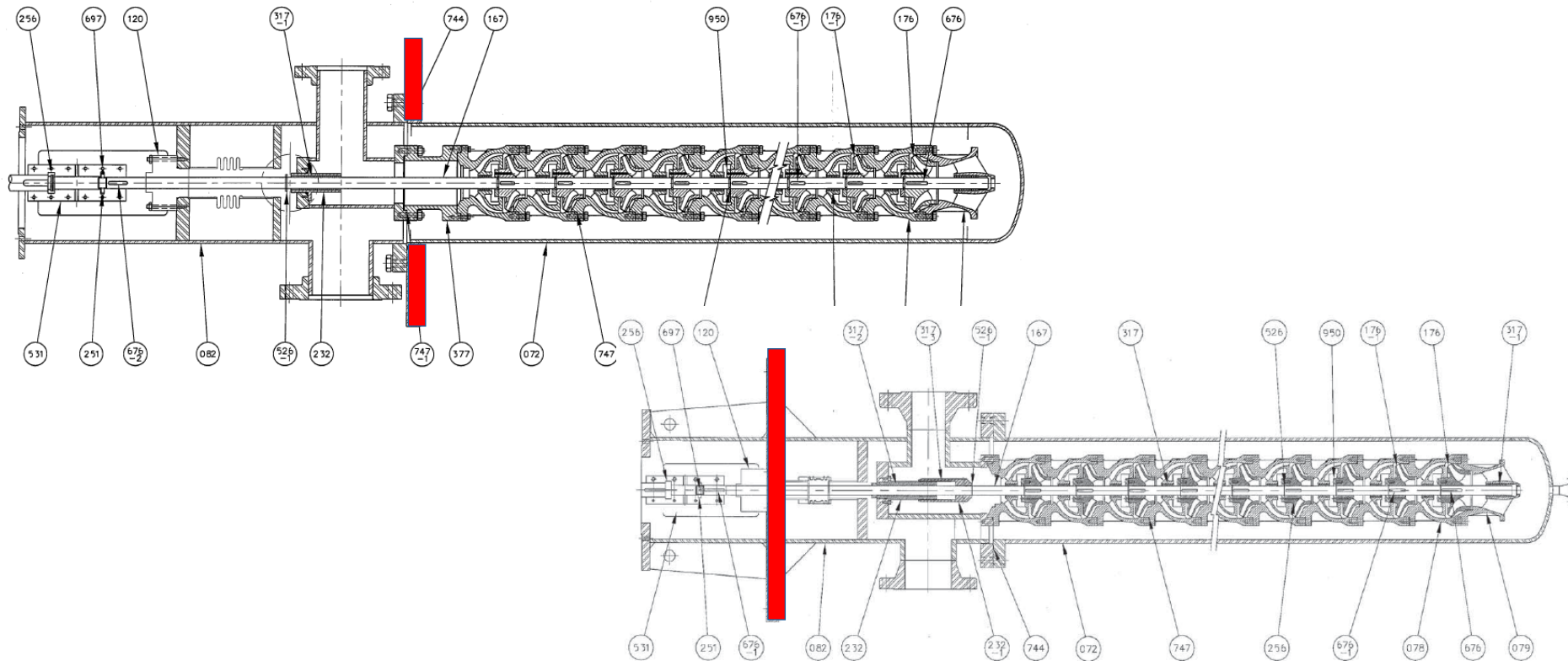
CLEAN ROOM

- For LOX service pump parts must be cleaned of any grease or oil (to avoid source of fire!)
- Ruhrpumpen Tulsa has a 'clean room' for doing that activity



EXAMPLE DRAWINGS

- Customer will often insulate the pump can and mount in a 'box'
- Depending on customer requirement the mounting plate can be placed above the nozzle (nozzle head will be inside the box and therefore pump is ready for startup without pre-cooling) or below the nozzles (nozzle head will be outside of the box)





**Cold Spin Test on
Cryogenic Pumps**

Liquid Oxygen Service

EFFECTIVENESS OF WARM-UP CHAMBER



EFFECTIVENESS OF WARM-UP CHAMBER





RP's Latest Customer for LOX Pumps



Submerged Motor Pumps for LNG & LPG Service

LNG Liquefaction Process

- Natural Gas is cyclically compressed and cooled until it liquefies
- This results in a very high pressure product that is not suitable for storage or transportation (too expensive)
- The pressure has to be lowered to atmospheric pressure by passing through a Joule Thompson Valve or through a Cryogenic Expander (similar to a reverse running pump)
- Results in Liquified Natural Gas (LNG) at -160C and atmospheric pressure which can be economically stored, transported and (later) regassified

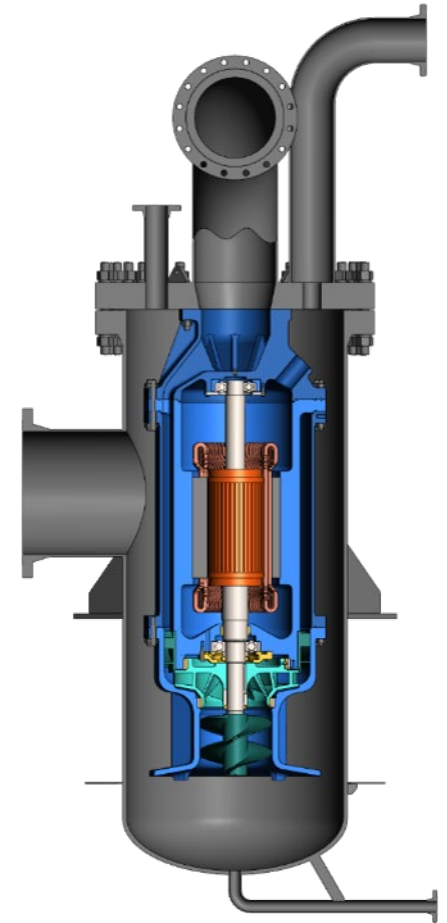
Why a Submerged Motor Design?

Conventional external motor, mechanically sealed vertical pumps (VS1 or VS6) for hazardous duties present risks and problems due to their design:

- Shaft seals may leak into the atmosphere
- Couplings may lead to misalignment (-160C inside the pump - +40C outside the pump)
- Bearing Lubrication System
- The motor must be explosion-proof
- Regulations require Top-Entry only into a tank or vessel. No side-entries are allowed.

Advantages of a submerged motor design:

- Elimination of shaft seals
- No alignment problems
- Compact size
- No bearing lubrication system required
- Reduced noise
- Explosion-proof motor not required
- High efficiency motor due to cryogenic temperatures.
- Performance tested on actual product pumped (LNG or LPG)



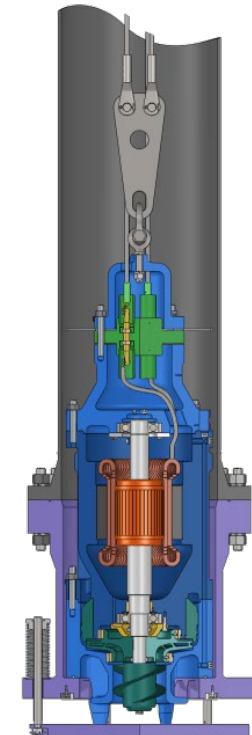
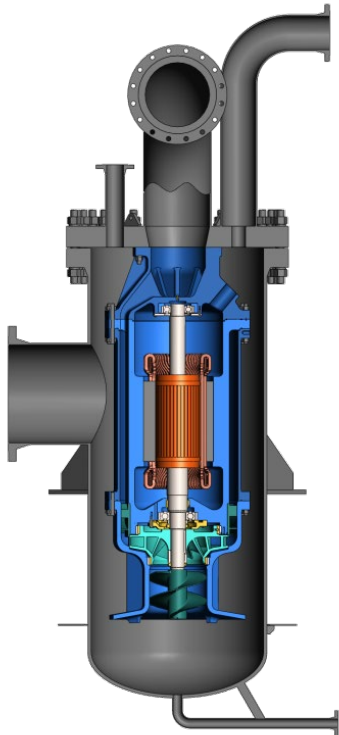
Submerged Motor Pumps

Who Makes them?

- Elliott (Ebara) Cryodynamics
(In-Tank, Suction Vessel Mounted, & Cargo Pumps)
- Nikkiso
(In-Tank, Suction Vessel Mounted and Small “Point of Sale” Pumps
(through subsidiary company ACD))
- Shinko (Cargo Pumps)

- Elliott & Nikkiso split the In-Tank & Suction Vessel Mounted pump market 50/50
- Shinko has 90% of the Cargo Pump market

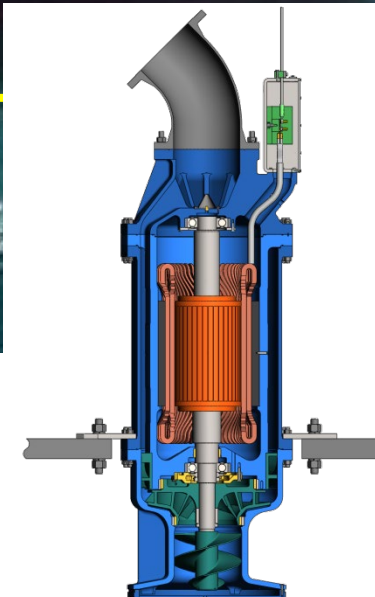
Liquefaction Pumps



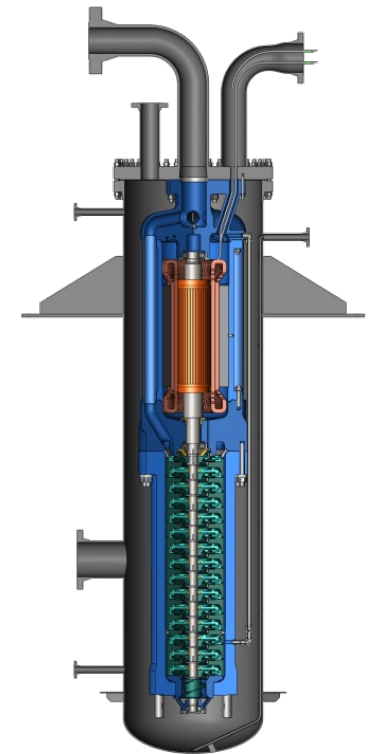
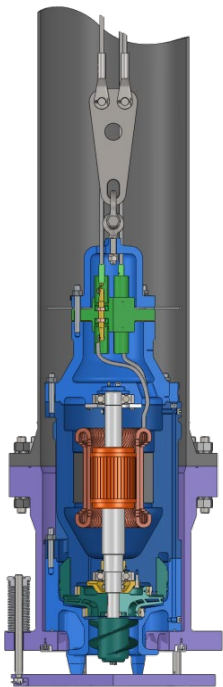
Marine Cargo Pumps



**MARINE CARGO &
SPRAY PUMPS**



Regasification Pumps

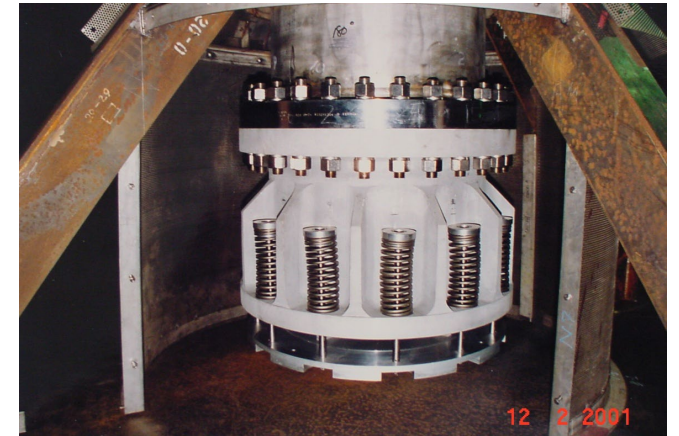
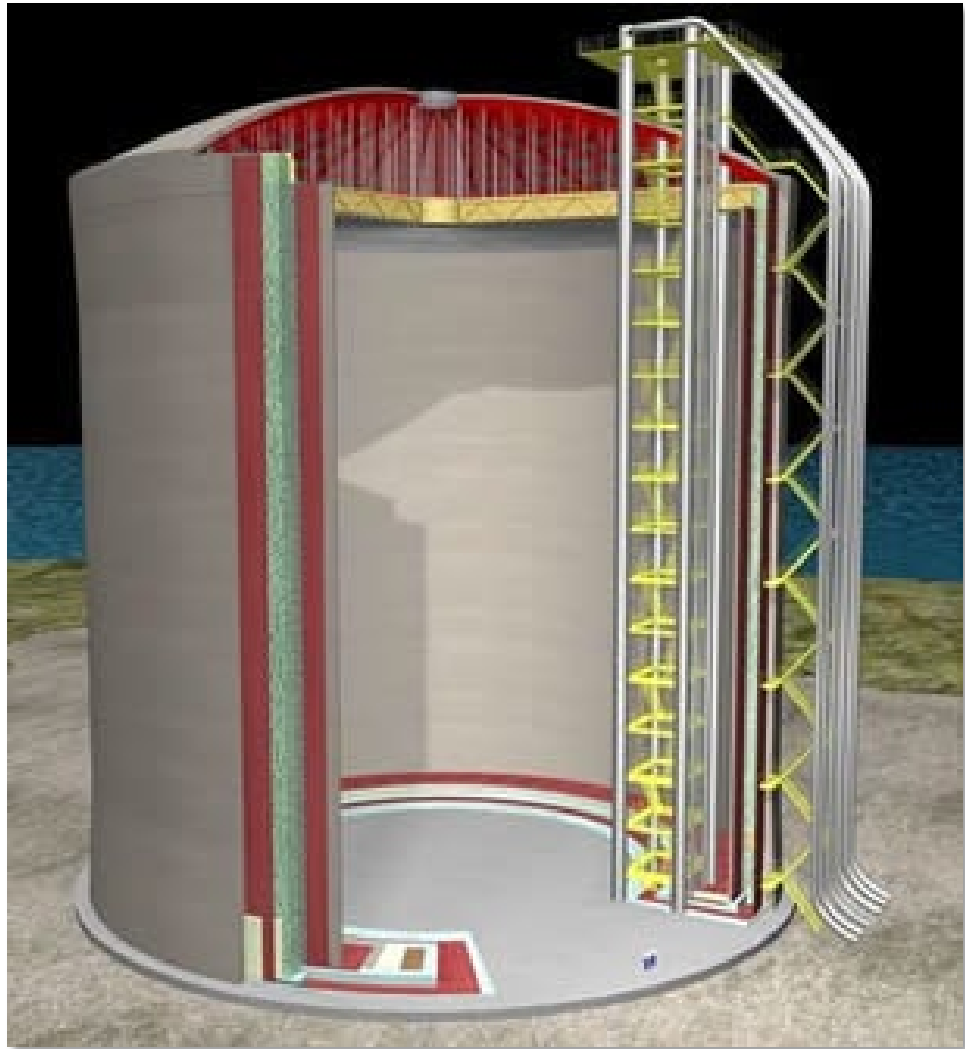


Floating Storage & Regasification Units (FSRU)

HIGH PRESSURE SEND OUT PUMPS



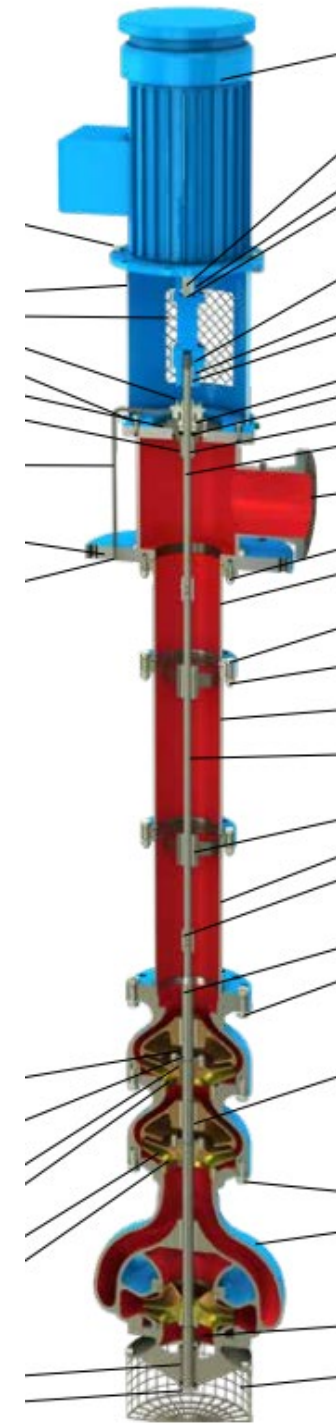
In-Tank Pumps



Why not a VS1 Pump?

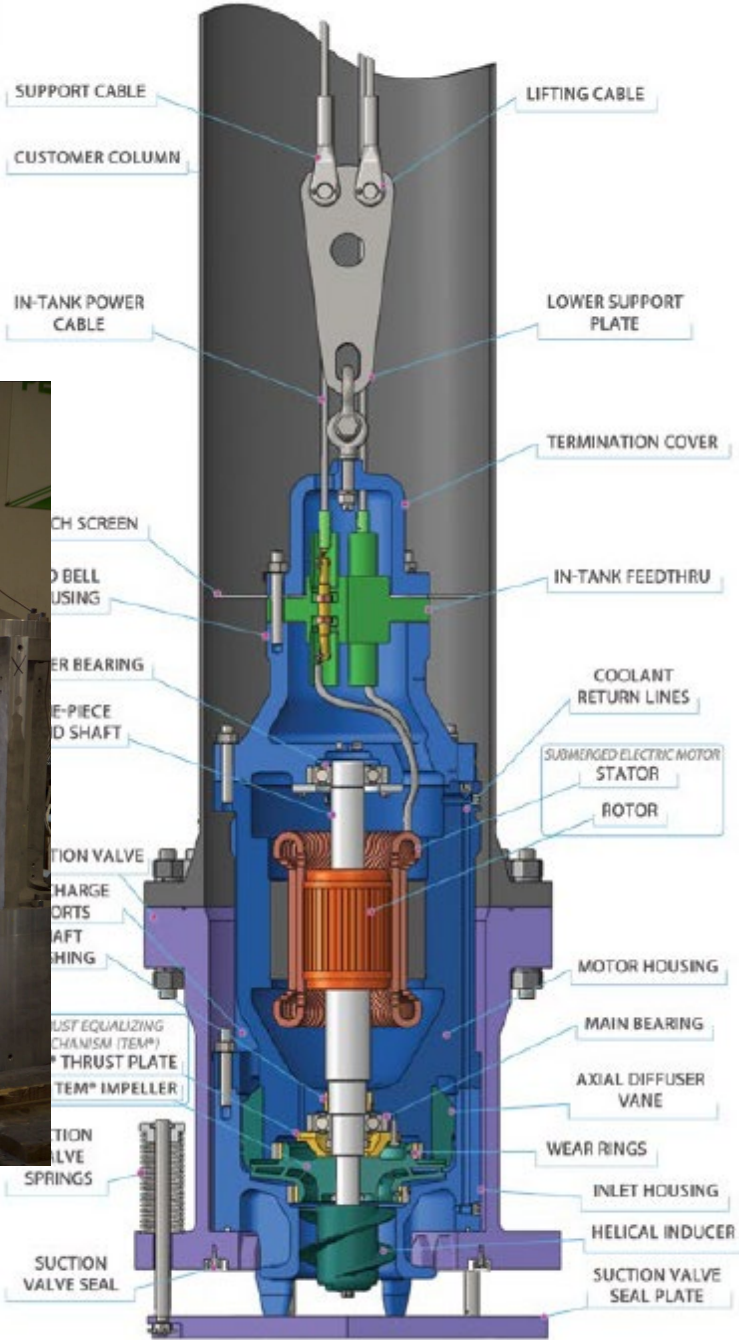
Some of the problems

- 40m of shafting and column pipe in 3m lengths with 1.5m bearing spacing
- Lineshaft bearing lubrication (40m too long for self lube bearings so enclosed type lineshaft. Lubricated by.....?)
- Practicality of handling all this shafting and column piping at the top of a 40m high tank for installation and removal for maintenance.
- Plan 53 reservoir needing weekly top up
- 4 Pole speed so large diameter multi stage pump
- Size of motor, thrust pot and nozzle head (wind issue?)



In- Tank Pumps

Qty – 3 per tank + warehouse spare
 (Typical Duty)
 Flow – 550m³/hr
 Head – 250m
 SG – 0.43 to 0.48
 Temp - -160 C
 Eff – 77% (overall, pump & motor)
 Rated Power 250kW
 Max Power 267kW
 Motor Power – 290kW 6600/3/50





HP Booster Pumps

Qty – 4 Plus Warehouse Spare

(Typical Duty)

Flow – 410m³/hr

Head – 2200m

SG – 0.42 to 0.47

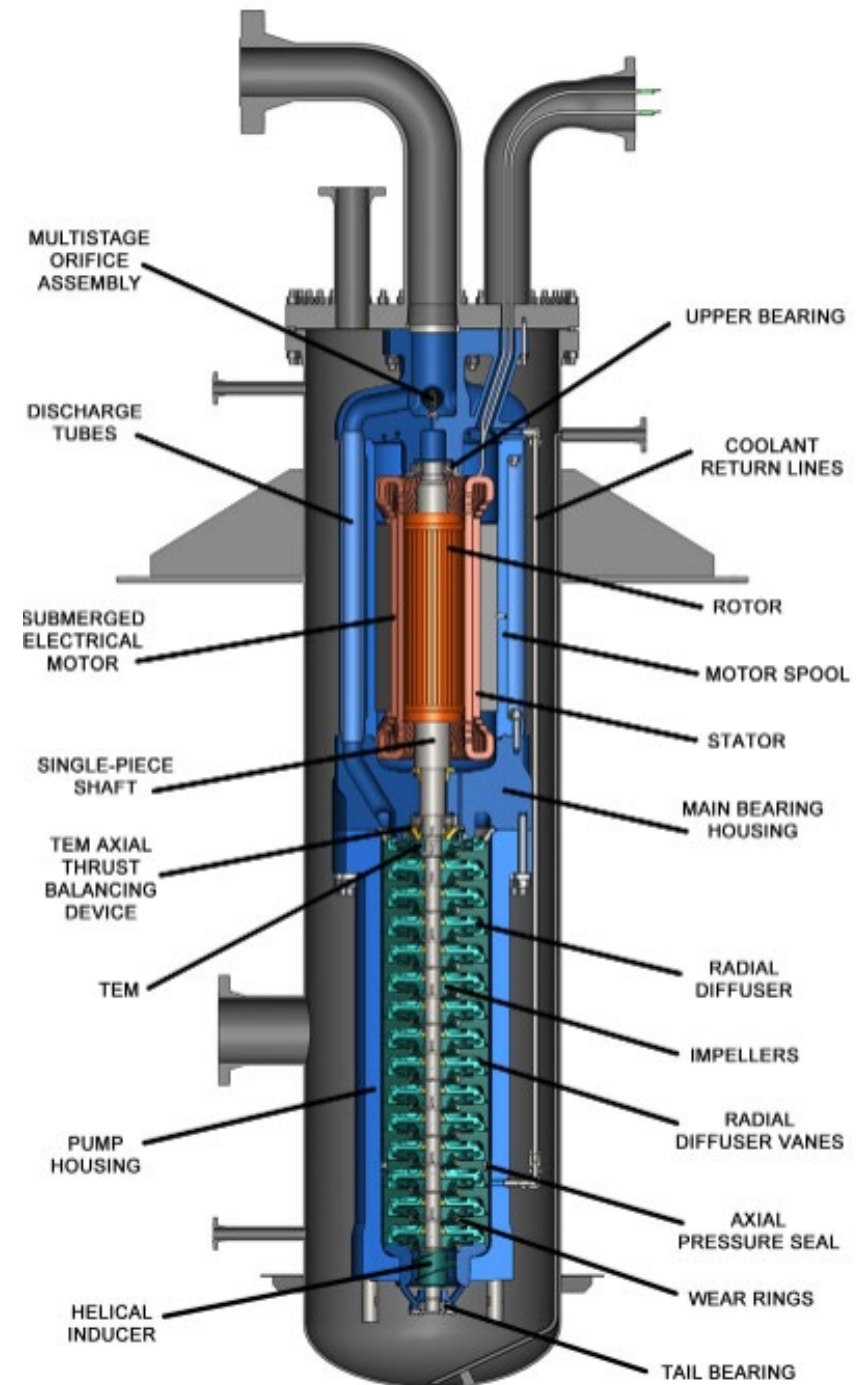
Temp - -155 C

Eff – 80%(overall, pump & motor)

Rated Power 1450kW

Max Power 1550kW

Motor Power – 1600kW 6600/3/50





HP Booster Pumps

Materials of Construction:

Headplate & Barrel – 304 / 304L

Flange Rating usually 900# (can be 1500#)

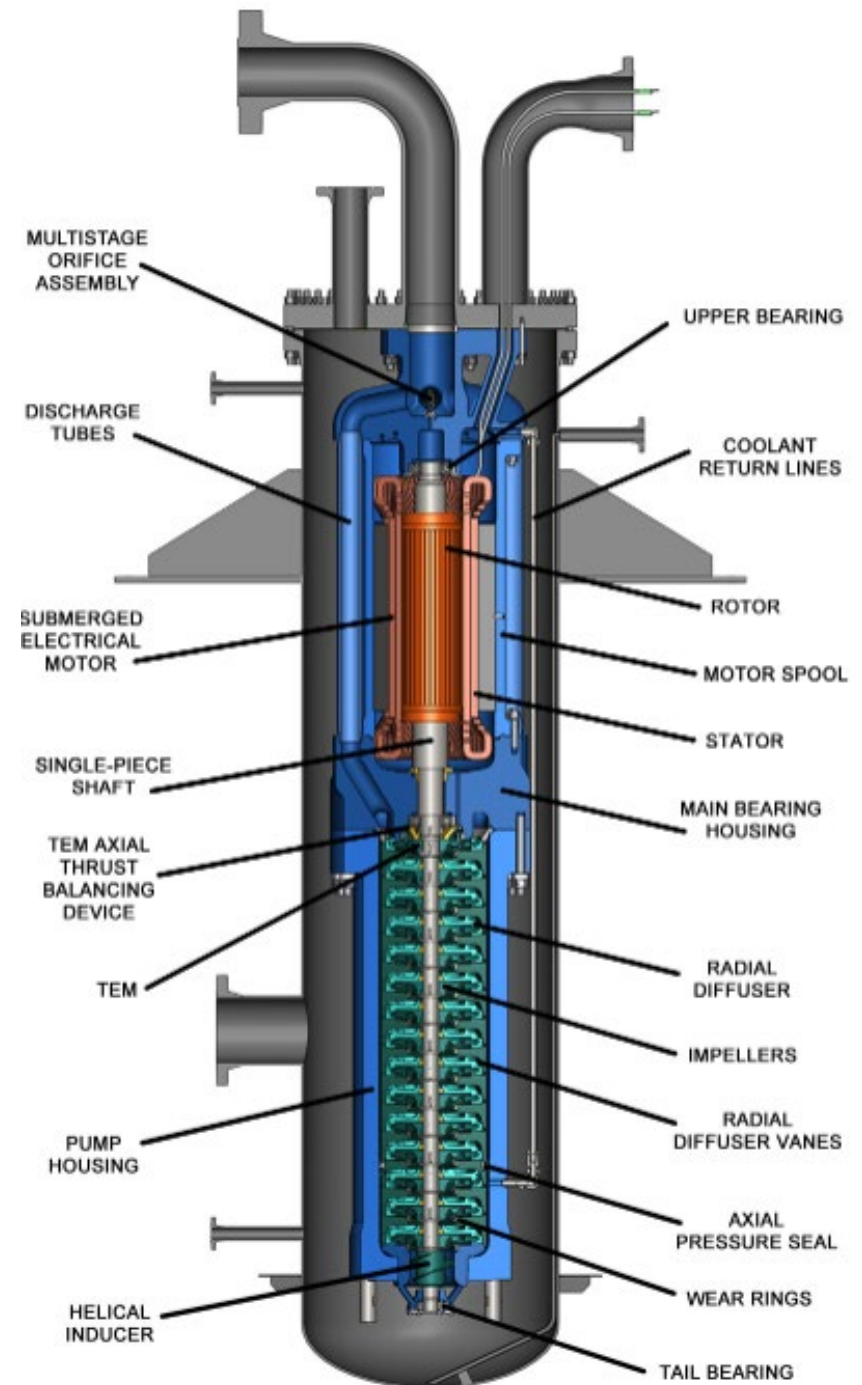
Diffusers, Impellers,

Motor Housing,

Pump Housing

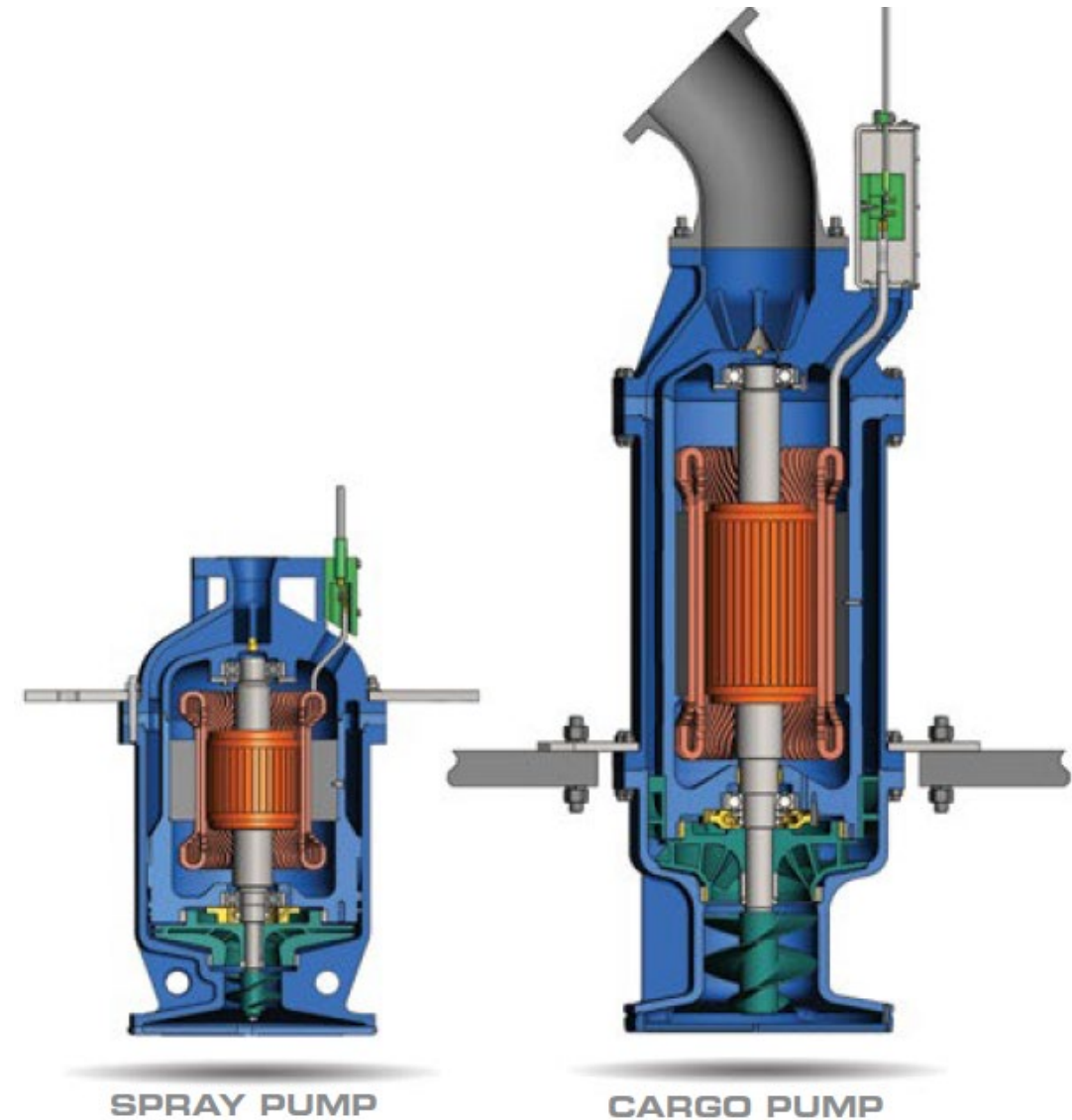
Aluminium Alloy

A356 –T6

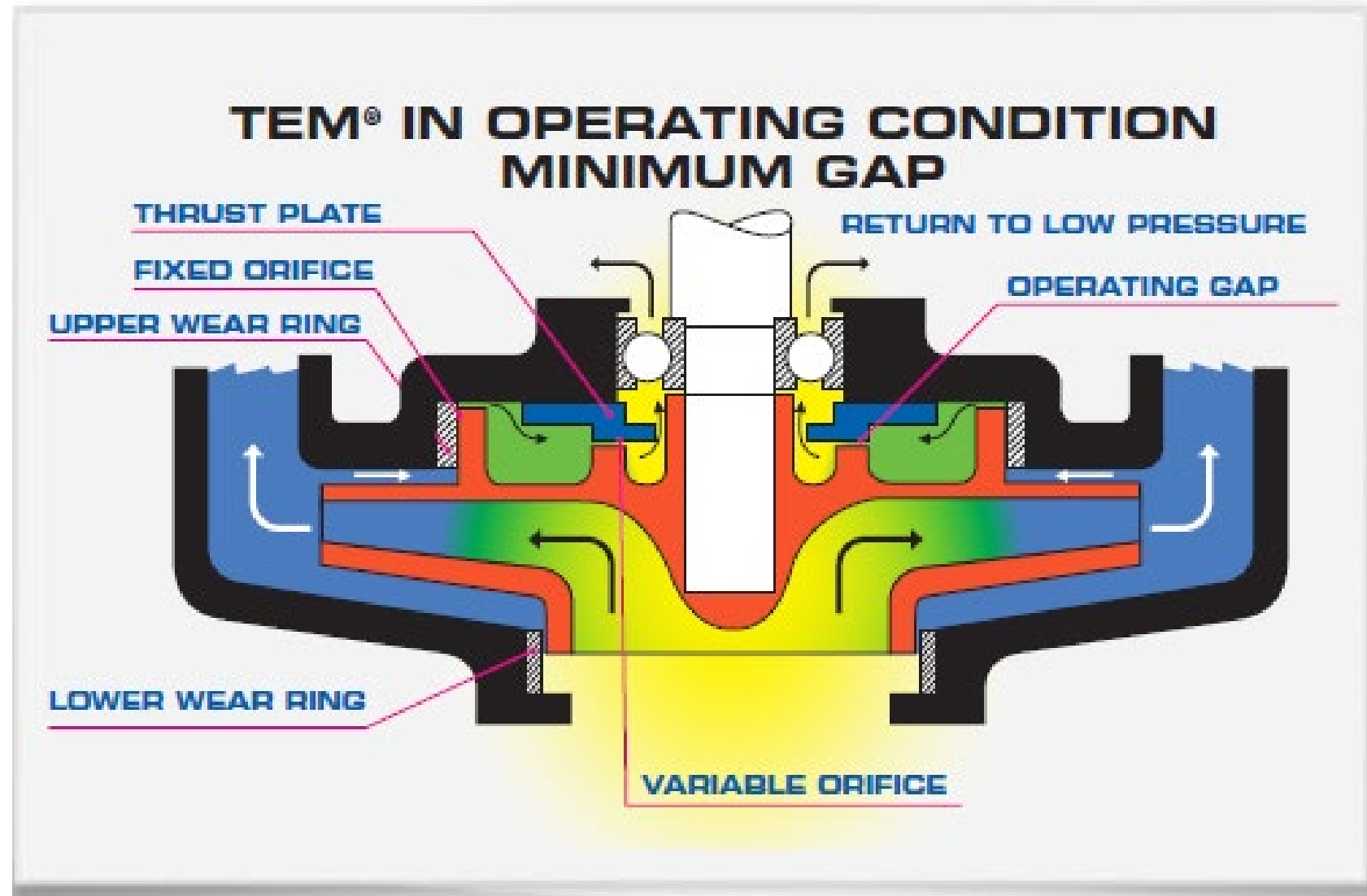


Marine Cargo Pumps

- 8 pumps fixed installation inside the LNG tanks of an LNG Carrier
- Elliott Ebara used to have 100% of this market
- Now 90% of the market is owned by Shinko (Japan)

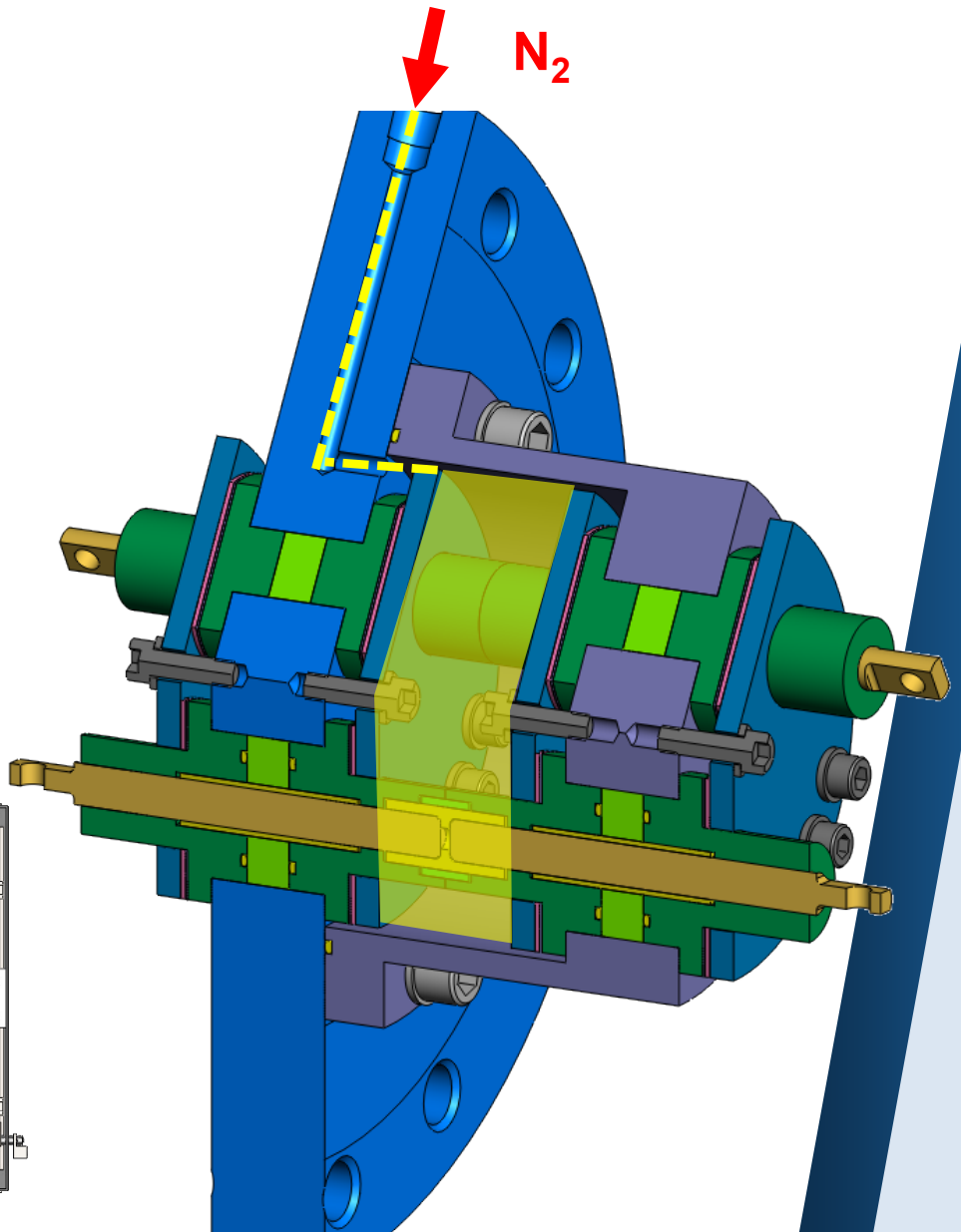
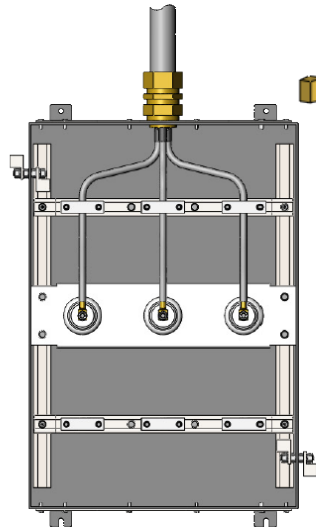
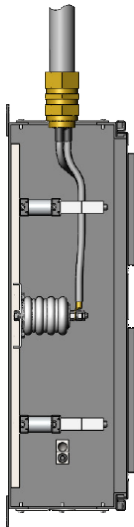
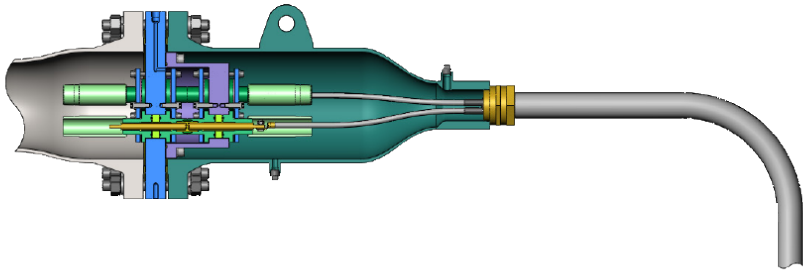


Thrust Balancing



Electrical Connections

Double Feedthru or Terminal Header (Schott)





Coming Attractions 😊

“Summer Break”

We are taking a break during the summer holiday period.

We will be back with more Short Courses at the end of August



Specialist for Pumping Technology

Q & A

www.ruhrpumpen.com

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RUHRPUMPEN AT A GLANCE

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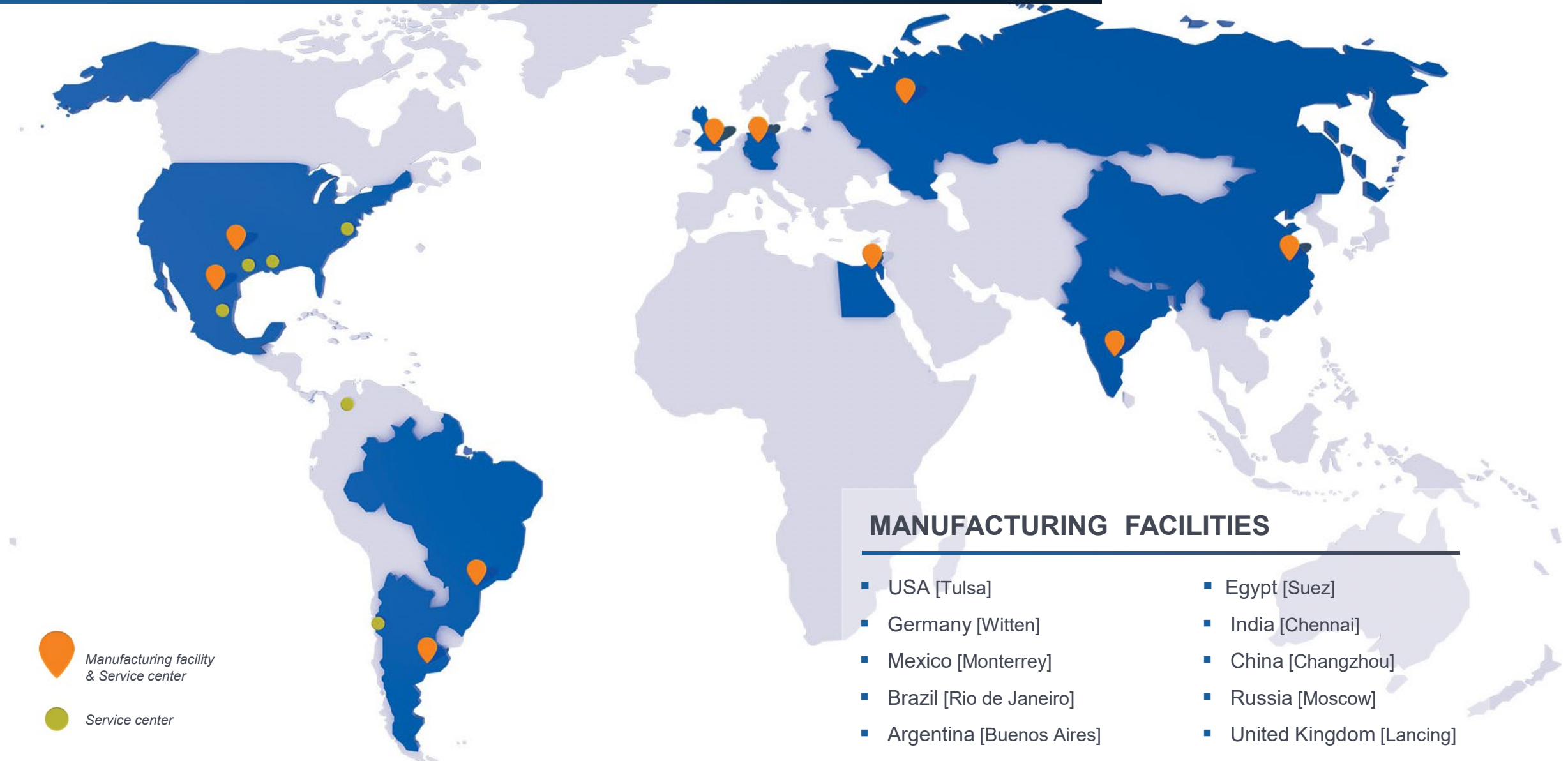
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EMPLOYEES**

**15 SERVICE
CENTERS**

+70,000 PUMPING SOLUTIONS INSTALLED WORLDWIDE

A GLOBAL COMPANY



MARKETS WE SERVE

Our commitment to create innovations that offer reliable solutions to our customers allow us to provide a complete range of pump systems to support **core markets** as:





OUR PUMP LINES

Ruhrpumpen offers a broad range of highly engineered and standard pumping products that meet and exceed the requirements of the most demanding quality specifications and industry standards.

Our pumps can handle head requirements as high as 13,000 ft (4,000 m) and capacities up to 300,000 gpm (68,000 m³/hr). Moreover, our pump designs cover temperatures from cryogenic temperatures of -310 °F (-196 °C) up to 752 °F (400 °C).

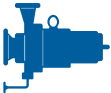
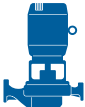
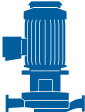


Products include:

- Single Stage Overhung Pumps
- Between Bearings Pumps
- Horizontal Multi-Stage Pumps
- Vertical Multi-Stage Pumps
- Vertical Mixed Flow & Axial Flow Pumps
- Positive Displacement Pumps
- Full Range of Industrial Pumps
- Submersible Pumps
- Magnetic Drive Pumps
- Decoking Systems
- Packaged Systems
- Fire Systems



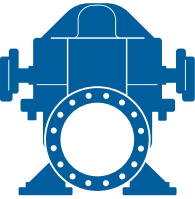
OVERHUNG PUMPS

CATEGORY	RP MODEL	DESIGN STANDARD	
Sealless Magnetic Drive Pumps	CRP-M / CRP-M-CC	ISO 2858 & 15783 HI design (OH11)	
	SCE-M	API 685	
Foot Mounted OH1 and General End Suction Pumps	IPP	HI design (OH1)	
	CPP / CPP-L	HI design (OH1) ANSI B73.1	
	CPO / CPO-L	HI design (OH1) ANSI B73.1	
	CRP	HI design (OH1) ISO 2858 & 5199	
	GSD	HI design (OH0)	
	SHD / ESK / SK / SKO SKV / ST / STV	HI design (OH1)	
	SWP	HI design (OH3A)	
Centerline Mounted	SCE	API 610 (OH2)	
Vertical In-Line Pumps	SPI	API 610 (OH3)	
	IVP / IVP-CC	HI design (OH4 / OH5)	
	IIL	HI design (OH5) Dimensionally compliant with ANSI B73.2	
	SPN	API 610 (OH5)	





BETWEEN BEARING PUMPS

CATEGORY		RP MODEL	DESIGN STANDARD	
1 and 2 stage	Axially split	HSC / HSD / HSL HSR / ZW	HI design (BB1)	
		HSM	HI design (BB3)	
		ZM / ZMS ZLM / ZME	API design (BB1)	
	Radially split	HVN / J	API design (BB2)	
		RON / RON-D	API design (BB2)	
Multi-stage	Axially split	SM / SM-I	API design (BB3)	
		JTN	API design (BB3)	
	Radially split <i>single casing</i>	GP	API design (BB4)	
	Radially split <i>double casing</i>	A LINE	API design (BB5)	





VERTICAL PUMPS

CATEGORY		RP MODEL	DESIGN STANDARD	
Single casing	Diffuser	VTP	HI & API 610 (VS1)	
		VCT	HI & API 610 (VS1)	
		HQ	HI & API 610 (VS1)	
		VLT	HI & API 610 (VS1)	
	Volute	DSV / DX	HI & API 610 (VS2)	
	Discharge through column – Axial flow	VAF	HI & API 610 (VS3)	
Double casing	Separate discharge line	VSP / VSP-Chem	HI & API 610 (VS4)	
	Diffuser	VLT / VMT	HI & API 610 (VS6)	
	Volute	DSV / DX	HI & API 610 (VS7)	
Submersible pumps		SMF	HI design (OH8A)	
		VLT-Sub / VTP-Sub	HI design (VS0)	





SPECIAL SERVICE PUMPS

CATEGORY	RP MODEL	DESIGN STANDARD	
Pitot tube pumps	COMBITUBE	HI design	
Reciprocating pumps	RDP	API 674 ISO 13710	
Vertical turbine generator	VTG	HI design (VS6)	
Barge	LS BARGE	HI design	
Floating dock pumps	ZVZ	HI design	
	LVZ	HI design	
Cryogenic pumps	SVNV	-	
	VTG Cryogenic	-	
	VLT Cryogenic VLTV	-	
Pre-packaged fire pump systems	Fire systems incorporate pumps, drivers, control systems and pipework in a single container. They can be skid mounted, with or without enclosure and supplied with electric motor or diesel engine.		 NFPA-20-850 UL and FM approved components

