

HS-16 - HS-20 - HS-32 - NHS-35 High Throughput Diffusion Pumps

User Manual



Notices

Manual Part Number

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Safety Notices

CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

WARNING

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met.

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About this manual

Validity

This manual lists the instructions for the users of the High Throughput Diffusion Pumps, with particular reference to the notions relating to safety, operation and first level maintenance, limited to maintenance operations for which the user is responsible.

The maintenance operations, illustrated in the specific sections, with specific provisions relating to the higher level of maintenance (personnel specifically trained for maintenance operations) must not be carried out by the user.

NOTE

- 1 This manual contains useful information so that all personnel using the High Throughput Diffusion Pumps can operate it safely and guarantee perfect efficiency, for its entire life span.
 - 2 Keep this manual, together with all the related publications, in an accessible place known to all operators/maintenance personnel.
-

Definitions and terminology

Definition of Caution, Warning and Note

Some important references of this manual are highlighted and framed in contrasting color.

WARNING



Warning messages draw the operator's attention to a specific procedure or practice which, if not performed correctly, could result in serious personal injury.

CAUTION

Caution messages are displayed before procedures which, if not observed, could cause damage to the equipment.

NOTE

Notes are intended to call attention to important information and provide more detail regarding specific steps.

Warning Symbols

The following is a list of symbols that appear in conjunction with warnings on the HS High Throughput Diffusion Pump. The hazard they describe is also shown.

A triangular symbol indicates a warning. The meanings of the symbols that may appear alongside warnings in the documentation are as follows:



Dangerous voltages



Hot surface



Generic hazard



Presence of dangerous substances



Crushing hazard



Cutting hazard



Wear protective gloves



Wear personal protective equipment



Wear accident-prevention shoes



European Declaration of Conformity















Waste Electrical and Electronic Equipment

Technical Information

The following symbol may be used on warning labels attached to the instrument. When you see this symbol, refer to the relevant operation or service manual for the correct procedure referred to by that warning label.



The following symbols appear on the instrument for your information.

	Corrosive substances
	Explosive Material
	Toxic Gases Asphyxiation
	Wear face shield
	Production date
	Dangerous voltages
	Hot surfaces
	Generic hazard
	CE certification
	Wear safety helmet
	RoHS China certification
	Waste Electrical and Electronic Equipment

Safety

This section contains the information, prescribed by the Low Voltage Directive 2014/35/EU, which is essential for the compliance and observance of the safety regulations both generally and in relation to the specific use of the product.

Failure to comply with these instructions and the other instructions contained in this manual may render the safety conditions envisaged in the design phase inefficient and cause accidents to those operating the product.

Agilent Technologies declines all responsibility for damage to the product or for the physical safety of the operator or third parties deriving from the non-observance of the safety rules indicated in the technical documentation.

Proper use

This manual contains important warnings and safety instructions to be observed in order for the unit to work safely.

The product described in this manual is intended exclusively for the area of application specified in the instructions. The manual also provides indications regarding the essential requirements for the application and operation of the product as well as the safety measures that can be adopted to guarantee regular operation. Agilent Technologies does not provide any guarantee or assume any responsibility for applications other than those described in this manual or in which the essential requirements and safety measures are not respected.

The product must only be used by qualified personnel who are able to take the necessary safety measures under conditions that do not cause damage or injury. Any accessories and equipment used with the product must be supplied or approved by Agilent Technologies.

Any adjustment or maintenance operation must be performed by a professional technician informed about the risks.

Repairs on the product must be carried out exclusively by Agilent authorized personnel.

Technical Information

Improper use

Agilent Technologies declines all responsibility, deriving from the improper use of the High Throughput Diffusion Pumps.

Improper use will cause all claims for liability and warranties to be forfeited.

Personnel responsible for pump operation and maintenance must be well-trained and must be aware of the accident prevention rules. The accident prevention precautions contained in this section must be continuously respected during operation and maintenance of the pump to avoid damage to operators and to the pump. These precautions are provided in the form of WARNING and CAUTION notes.

WARNING



Operating procedures, technical information and precautions which, if not respected and/or implemented correctly may cause body harm to operators.

CAUTION

Operating procedures, technical information and precautions, which, if not respected and/or implemented correctly, may cause damage to the pump.

Disposal

Meaning of the "WEEE" logo found in labels.

The following symbol is applied in accordance with the EC WEEE (Waste Electrical and Electronic Equipment) Directive.

This symbol (valid only in countries of the European Community) indicates that the product it applies to must NOT be disposed of together with ordinary domestic or industrial waste but must be sent to a differentiated waste collection system. The end user is therefore invited to contact the supplier of the device, whether the Parent Company or a retailer, to initiate the collection and disposal process after checking the contractual terms and conditions of sale.



Figure 1 Logo "WEEE"

For more information refer to:

<http://www.agilent.com/environment/product/index.shtml>

Service

Should a customer need an advanced exchange or repair service, please contact local distributor or directly mail to

vpt-customer care@agilent.com

vpl-customer care@agilent.com

Completion of the "Request for Return" form is required to return your pump to Agilent for service (provided at the end of this manual).

Diffusion Pump Hazards

Designers of systems utilizing diffusion pumps must design out hazards wherever possible. For hazards that cannot be designed out, warnings, procedures, and instructions on proper use and servicing are provided. Please use guards, safety features, and interlocks as recommended.

Refer to Table 1 for a list of general hazards and recommended actions, Table 2 for a list of prohibited actions that can result in explosions, and Table 3 for a list of pressurization hazards that can result in damage to equipment.

The end user must ensure the pump is properly protectively bonded to the end product's protective earthing system as determined in the end product standard for the End Product Design. End Product Design provides a compliant fire enclosure as defined in the End Product's standard.

THE INSTALLATION, OPERATION, AND SERVICING OF DIFFUSION PUMPS INVOLVES ONE OR MORE OF THE FOLLOWING HAZARDS, ANY ONE OF WHICH IN THE ABSENCE OF SAFE OPERATING PRACTICES AND PRECAUTIONS, COULD POTENTIALLY RESULT IN DEATH OR SERIOUS HARM TO PERSONNEL.

Table 1 General Hazards

Hazard	Suggested Corrective Action
Loss of utility: water and/or electricity	Provide sufficient backup water and power supply as necessary to effect a safe shutdown under worst case conditions
Overpressure in foreline	Provide an interlock to ensure that the power supply to the pump heater cannot be activated if the foreline pump is not running and/or the pressure in foreline is above 0.5 Torr (0.67 mbar)
Overtemperature	Fit temperature sensors and pump fluid level sensors with a feedback to an interlock on the heater power supply
Insufficient water flow through the main cooling coils	Use water flow sensor and feedback to interlock the heater power supply
Water trapped between inlet and outlet of Quick Cool coil, or liquid nitrogen trapped between inlet and outlet of liquid nitrogen trap	Provide vent or pressure relief valves for both Quick Cool coil and liquid nitrogen trap
Loss of electrical ground integrity	Incorporate ground fault interrupt circuit into heater power supply
Positive pressure in pumping system	Integrate pressure relief valve in vacuum system
High voltage	Prevent personnel contact with high voltages; design and attach warnings
Toxicity and Corrosivity	Vent toxic and/or corrosive gases to a safe location; ensure adequate dilution or scrubbing to safe levels; take all actions required to meet air quality standards
Explosion	Integrate pressure relief valves Do not use hydrocarbon-based pumping fluids

Explosion

- Operation of the diffusion pump without continuous evacuation below 0.5 Torr (0.67 mbar), or without coolant and introducing a strong oxidizer (such as air) or explosive vapors or powders or materials which may react with pumping fluids in a hot pump (above 300 °F or 150 °C) can cause an explosion. Such an explosion can violently expel valves and other hardware, slam open doors that are not designed for appropriate pressure relief, or burst other components of the vacuum system. Serious injury or death may result from expelled parts, doors, shrapnel, and shock waves.
- Three elements are required for explosion: fuel, oxidizer, and an ignition. A combination of temperature and pressure can be a source of ignition. Most diffusion pump fluids are fuels. Hydrocarbon fluids are more prone to oxidize and explode than synthetic silicone-based fluid. The oxidizer can be air, which can be introduced by a leak, deliberately brought in via a process, or inadvertently admitted by operator error.
Oxygen and other strong oxidizers are even more dangerous than air. Certain conditions of temperature and pressure can cause a combustible mixture to explode. The larger the diffusion pump, the greater the risk of explosion and the greater the risk of damage and injury. Never operate large diffusion pumps utilizing hydrocarbon oils without a complete safety analysis for the entire system and for the application.
- Explosion and Fire from Acetone and Alcohol: Diffusion pumps are typically cleaned with acetone and alcohol. When combined with air, oxygen, and other oxides, alcohol and most other solvents are very flammable and explosive. Never permit any trace of these cleaners to remain in or on the pump. Always remove all traces of alcohol and acetone and other cleaners with clean, dry, oil-free compressed air

Technical Information

Never operate a large diffusion pump under the conditions listed in the following table. Any of these situations increases the probability of an explosion.

Table 2 Explosive Conditions

Hazard	Suggested Corrective Action
Do not run pump without cooling water	Overtemperature
Do not run pump with low level of pump fluid	Overtemperature
Do not run pump without proper backing or holding pump	Overpressure
Do not run pump when not evacuated below 0.5 Torr (0.67 mbar)	Overpressure
Do not admit air to, or rough through, a pump with hot boiler	Overpressure plus strong oxidizer
Do not open drain or fill plug while pump is under vacuum, especially when it is hot	Overpressure plus strong oxidizer
Do not contaminate pump with explosive vapors	Lower explosive threshold of gas mixtures
Do not remove, defeat, or override safety counter-measures such as pressure and thermal switches and valve sequencer interlocks	Overtemperature, overpressure, more combustible mixtures
Do not machine or weld any part of the pump without removing all fluid or solvent residue in pump	Source of ignition
Do not use unsuitable pumping fluid	Lower explosive threshold of gas mixture

Pressurization Hazards

Large vacuum pumps and their components are designed for vacuum service. They are not designed for pressurization, which could cause them to burst possibly expelling shrapnel at lethal velocities. Serious accidents have been caused by intentional pressurization of vacuum systems and their components.

- Never pressurize any part of a vacuum system for test or any other purpose.
- Always provide pressure relief when designing diffusion pumps into systems and ensure that pressure relief motion is limited to safe envelopes.
- Never permit the hazards in the following table to develop.

Table 3 Pressurization Hazards

Hazard	Suggested Corrective Action
Do not block inlet or vent of liquid nitrogen trap and lines	LN ₂ trap and/or lines burst
Do not close isolation valves at inlet and discharge of main water cooling coils when pump is heated	Water turns to steam and bursts coils
Do not pressurize the pump body (above 1 atm.)	Body of pump bursts
Do not make a hole through the vacuum wall	Loss of structural integrity of wall

- **Pressure Relief Devices:** Systems must be designed with pressure relief devices to provide safe pressure relief from internal explosions. Always recognize that safety devices can fail or malfunction. Provide redundant protection by installing devices having different failure modes, failure mechanisms, and failure causes. Be certain that exhaust duct materials are capable of withstanding the corrosiveness, temperature, and pressure of exhausted products.

Dangerous Substances

- **Chemical Dangers of Acetone and Alcohol:** Diffusion pumps are typically cleaned with acetone or alcohol. Acetone, alcohol, and most other solvents are irritants, narcotics, and depressants, and/or carcinogenic. Their inhalation and ingestion may produce serious effects. Even absorption through the skin can result in moderate toxicity. Always ensure that cleaning operations are performed in large, well-ventilated rooms. Use of self-contained breathing apparatus may be necessary, depending upon the solvent type and vapor concentration in surrounding air.
- **Poisonous and Corrosive Compounds:** When pumping poisonous, reactive, and/or corrosive gas, vapors, or chemicals, proper operation and regeneration do not always ensure that all hazardous materials have been totally removed. If hazardous gas, vapors, chemicals, or combustible mixtures are pumped, sufficient quantities may exist during operation or remain after regeneration to cause severe injury or death.
- **Pump Fluids:** Overheating the pump fluid, exposing it to air or reactive materials, or over-pressurizing it above the normal operating range, approximately 1×10^{-3} Torr (1.3×10^{-3} mbar) decomposes the fluid and possibly makes it toxic. This is especially true of backstreamed mechanical pump fluids which are more volatile (unstable). Overheating of accidentally introduced or backstreamed mechanical pump fluids cannot be protected against by thermal switches which are set for diffusion pump fluid.
- **Process Gases:** Process gases are frequently toxic, flammable, corrosive, explosive, or otherwise reactive. Agilent has no control over the types of gasses passing through the user's diffusion pump as these are entirely under the control of the process user and/or the hardware systems integrator. Since these gasses can cause serious injury or death, it is very important to plumb the exhaust of the pump to the facility's hazardous gas exhaust system which incorporates appropriate filters, scrubbers and similar components to ensure that the exhaust meets all air and water pollution control regulations.

Technical Information

High Temperatures

- **Hot Surfaces:** Boiler temperatures reach 530 °F (275 °C) which can cause serious burns. Always ensure that surfaces have cooled to near room temperature before touching them.
- **Hot Cooling Water and Steam:** The water used to cool the pump can reach scalding temperatures. Touching or rupture of the cooling surface can cause serious burns. Water left inside Quick Cool coils from previous use turns to steam when the pump is reheated. This steam must be allowed to escape without contacting personnel. Whenever possible, design the water system with interlock valves so that power cannot be applied to the pump unless water is flowing in the main cooling coils (not Quick Cool coils).

High Voltages

- Diffusion pump heaters operate at voltages (up to 480 V) high enough to kill. Design systems to prevent personnel contact with high voltages. Securely attach prominent hazard warnings. Personnel should always break the primary circuit to the power supply when direct access to the heater or wiring is required.

Large Equipment and Heavy Weights

- The lifting and moving of large diffusion pumps requires power-assisted equipment and the use of trained moving and installation personnel to avoid dropping, slipping, and overturning the pump. Pumps weigh in excess of 500 lbs (226.8 kg) and are 3 to 6 feet in their largest dimension (1 to 2 meters). Their mishandling can cause severe injury. Check the weight of the equipment before lifting and assure that the power-assist device is adequate for the task. Do not stand under the equipment being lifted and moved.

Diffusion Pump Description

Diffusion pumps are used where throughput for heavy gas loads is important. The diffusion pumps begin to work at approximately 10^{-3} Torr after a mechanical backing pump has exhausted most of the air in the system.



Figure 2 HS-20 Diffusion Pump

There are no moving parts in a diffusion pump, the heart of which is the multistage jet assembly, a group of concentric cylinders that are capped to leave small openings through which vapor can be deflected down and out toward the pump walls. A cold cap, mounted on top of the jet assembly helps keep pump fluid vapor out of the evacuation chamber. The pumps are water-cooled.

The vacuum fluid heater is mounted at the bottom of the pump body. The pumps also have a fill and drain assembly, and thermal protection switches. The inlet is at the top, and the exhaust is through the foreline.

Pump Operation

The diffusion pump works by heating the pump fluid to its boiling point. The vapors travel upward inside the jet assembly and are accelerated out and downward through the jet nozzles toward the cool outer walls of the pump, where the vapor condenses back into a fluid. As the vapor passes the inlet, it picks up elements of the gas to be exhausted and carries them to the ejector and out of the pump via the foreline. The pump's ability to reach low pressures is governed in part by the inlet size. The gas migrates by thermal motion and is captured and expelled, thus lowering the pressure in the evacuation vessel.

Large diffusion pumps achieve a vacuum using a five-stage jet assembly consisting of four diffusion stages and one ejector stage. The cold cap and body are water cooled. Optional stainless steel Quick Cool coils quickly suppress boiling by cooling the heater; they require an independently valved water supply.

Technical Specifications

The Technical Characteristics of the large diffusion pumps are given in Table 4. The graphs in Figure 3 through Figure 6 show air speed and throughput as a function of inlet pressure. The dimensions of the inlet flange that connects to the system to be evacuated are given in Table 6 through Table 12.

NOTE

The data in Table 4 refers to pumps charged with DC-704 diffusion pump fluid.

Table 4 Technical Specifications


Specification	Units	HS-16, 8.1 kW	HS-16, 9.6 kW	HS-20	HS-32	NHS-35
Operating Range	Torr mbar	1.6×10^{-3} to $< 5 \times 10^{-8}$ 2.1×10^{-3} to $< 7 \times 10^{-8}$	2.0×10^{-3} to $< 5 \times 10^{-8}$ 2.7×10^{-3} to $< 7 \times 10^{-8}$	1.3×10^{-3} to $< 5 \times 10^{-8}$ 1.7×10^{-3} to $< 6.7 \times 10^{-8}$	1.7×10^{-3} to $< 5 \times 10^{-8}$ 2.3×10^{-3} to $< 7 \times 10^{-8}$	9.0×10^{-4} to $< 5 \times 10^{-8}$ 1.2×10^{-3} to $< 7 \times 10^{-8}$
Pumping Speed, ISO Standard 1608/1 *	l/s, Air l/s, Helium	6000 7500		10,000 12,500	17,300 21,265	28,000 35,000
Throughput (Air), Max. Optimum Range	Torr-l/s mbar-l/s	9.5 12.7	12.0 16.0	12.5 16.7	30.0 40.0	25.0 33.0
Overload Range (@ 1×10^{-2} Torr)	Torr-l/s mbar-l/s	11.5 15.3	13.5 18.0	18.0 23.0	35.0 45.0	35.0 45.0
<div>CAUTION</div> <div>Extended operation of pumps in the <i>Overload</i> condition may result in breakdown of the top jet and resultant fluid loss through the foreline.</div> <div></div>						
Forepressure, Max. No Load	Torr mbar	0.65 0.86		0.65 0.86	0.50 0.66	0.55 0.73
Full Load	Torr mbar	0.55 0.73		0.55 0.73	0.35 0.46	0.40 0.53
Backstreaming Rate at Pump Inlet (within Optimum Operating Range)	mg/cm ² /min	<0.0015		<0.0015	<0.0007	<0.0005
Electrical Power AC, 50/60 Hz, 3 phase	kW	8.1	9.6	12	24	24
Cooling Water Flowrate @ Inlet Temperature of 60 to 80 °F	gpm (US)	1.5 Body and Cold Cap		1.5 Body and Cold Cap	Body 4.0 Cold Cap 1.5	Body 4.0 Cold Cap 1.5
For the AVS pumping speed results, see the Agilent Vacuum Products catalog.						

Table 4 Technical Specifications (Continued)

Specification	Units	HS-16, 8.1 kW	HS-16, 9.6 kW	HS-20	HS-32	NHS-35
Warmup Time	minutes	30		4.5	60	60
Cooldown Time Without Quick Cool With Quick Cool	minutes	48 30		8.5 4.5	180 60	180 60
	qt (US) liters	3 2.8		5 4.7	12 11.4	12 11.4
Recommended backing pump capacity**	cfm	80		100	300	300
**Recommended sizes when operating at maximum throughput.						
Weight	lbs (kg)	500 (227)		600 (272)	1350 (612)	1500 (682)
Jet Assembly		5-stage Aluminum	5-stage Aluminum	5-stage Stainless Steel	5-stage Stainless Steel	5-stage Stainless Steel
Materials		Body, Flanges, M/S-foreline baffle S/S Body, Cooling coils, Copper Cod cap, Nickel plated copper		S/S	Body, Flanges, M/S Body, Cooling coils, Copper Cod cap, Nickel plated copper	Body, Flanges, Foreline baffle M/S Body, Cooling coils, Copper Cod cap, Nickel plated copper
Thermal Switches		Upper (water) auto reset 185 ° F (85 °C) Lower (boiler) auto reset 390 °F (199 °C)			Upper (water) auto reset 220 ° F (104 °C) Lower (boiler) auto reset 550 °F (288 °C)	Upper (water) auto reset 200 ° F (93 °C) Lower (boiler) auto reset 600 °F (316 °C)
Water Connections		1/4" FPT			3/8" FPT	
Environmental		Maximum ambient temperature 113 °F (45 °C)				
Installation		Indoor use, Installation Category 2, Pollution Degree 2				
Altitude		6562' (2000 m)				

Pump Air Speed and Throughput

The pumping function is graphically described by relating inlet pressure to both air speed and throughput. This relationship is shown for the large vacuum pumps in the set of graphs shown in Figure 3 through Figure 6.

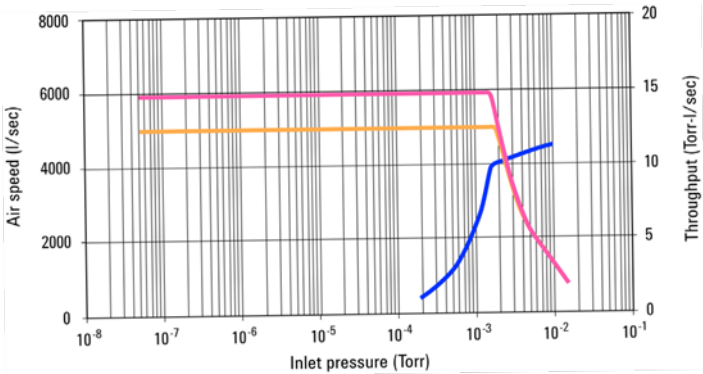


Figure 3 HS-16 Speed and Throughput Curves, 8.1 kW

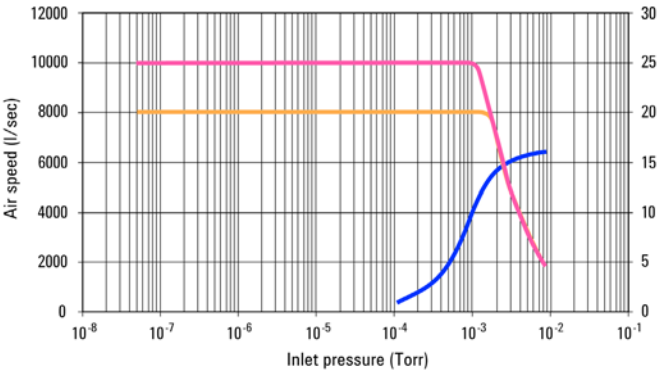


Figure 4 HS-20 Speed and Throughput Curves

Technical Information

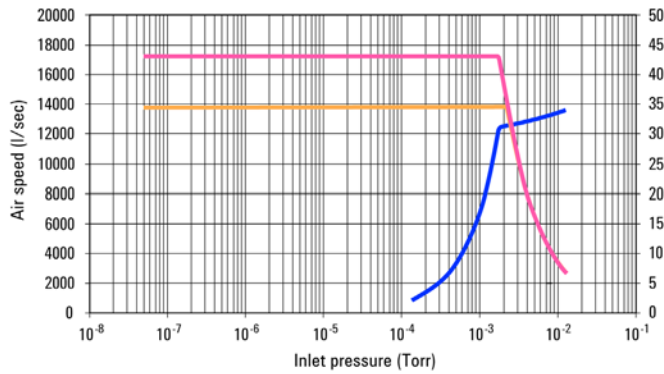


Figure 5 HS-32 Speed and Throughput Curves

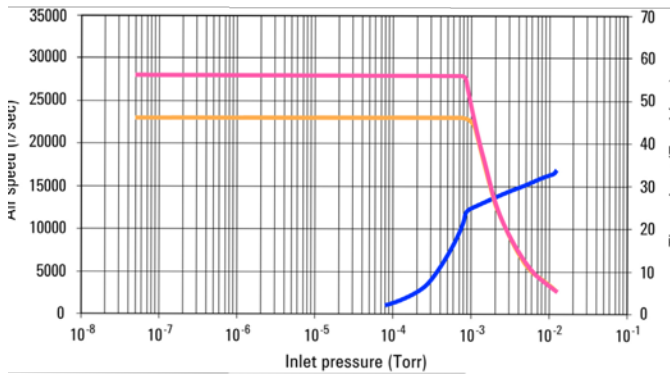


Figure 6 NHS-35 Speed and Throughput Curves

Technical Information

Physical Specifications

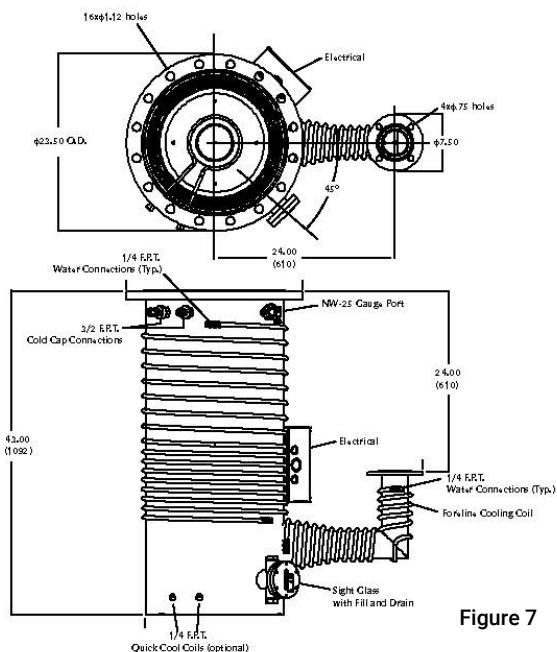


Figure 7 HS-16 Outline with ASA Flanges

Table 5 HS-16: Dimensions and Weights

	Units	HS-16
Height, minimum including clearance for heater access	in (mm)	51 (1295.4)
Weight	lbs (kg)	500 (227)
Connections: Body and Foreline Quick Cool coils	in in	1/4 FPT 1/4 FPT

Table 6 HS-16 Flange Dimensions

		ASA		ISO	
	Units	Inlet	Foreline	Inlet, 500 K	Foreline, 100 K
OD	in (mm)	23.50 (596.9)	7.50 (190.5)	21.65 (549.9)	5.12 (130.1)
ID	in (mm)	18.00 (457.2)	3.58 (90.9)	18.00 (457.2)	3.58 (90.9)
Thickness	in (mm)	1.00 (25.4)	0.50 (12.7)	0.67 (17.0)	0.47 (11.9)
Bolt Circle	in (mm)	21.25 (539.8)	6.00 (152.4)		
No. of Holes		16	4		
Size of Holes	in (mm)	1.13 (28.7)	0.75 (19.1)		
Orientation	Holes straddle center line of foreline				
Gasket Groove ID	in (mm)	18.69 (474.7)	4.31 (109.5)	Requires NW-500	Requires NW-100
Width	in (mm)	0.37 (9.4)	0.30 (7.6)	Centering Ring (not	Centering Ring (not
Depth	in (mm)	0.18 (4.6)	0.14 (3.6)	included with pump)	included with pump)

Technical Information

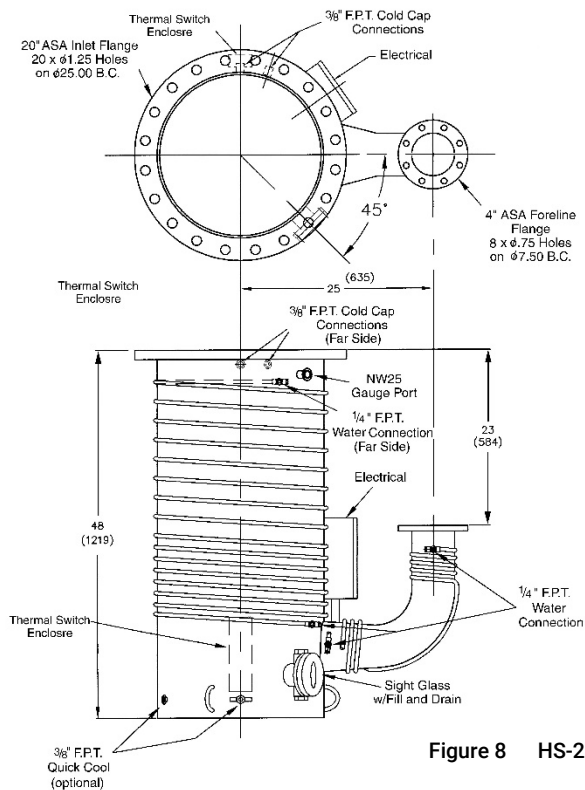


Figure 8 HS-20 Outline with ASA Flanges

Table 7 HS-20: Dimensions and Weights

	Units	HS-20
Height, minimum including clearance for heater access	in (mm)	56 (1422)
Weight	lbs (kg)	600 (272.2)
Connections:		
Body and Foreline	in	1/4 FPT
Quick Cool coils	in	3/8 FPT

Table 8 HS-20 Flange Dimensions

		ASA		ISO	
		Inlet	Foreline	Inlet, 630 K	Foreline, 160 K
OD	in (mm)	27.50 (698.5)	9.00 (228.6)	27.17 (690.1)	7.09 (180.1)
ID	in (mm)	21.25 (539.8)	5.06 (128.5)	21.25 (539.8)	5.06 (128.5)
Thickness	in (mm)	1.12 (28.5)	0.75 (19.1)	0.78 (19.8)	0.47 (11.9)
Bolt Circle	in (mm)	25.00 (635.0)	7.50 (190.5)		
No. of Holes		20	8		
Size of Holes	in (mm)	1.25 (31.8)	0.75 (19.1)		
Orientation	Holes straddle center line of foreline				
Gasket Groove ID	in (mm)	21.63 (549.4)	5.31 (134.9)	Requires NW-630	Requires NW-160
Width	in (mm)	0.48 (12.2)	0.38 (9.7)	Centering Ring (not	Centering Ring (not
Depth	in (mm)	0.25 (6.6)	0.09 (2.3)	included with pump)	included with pump)

Technical Information

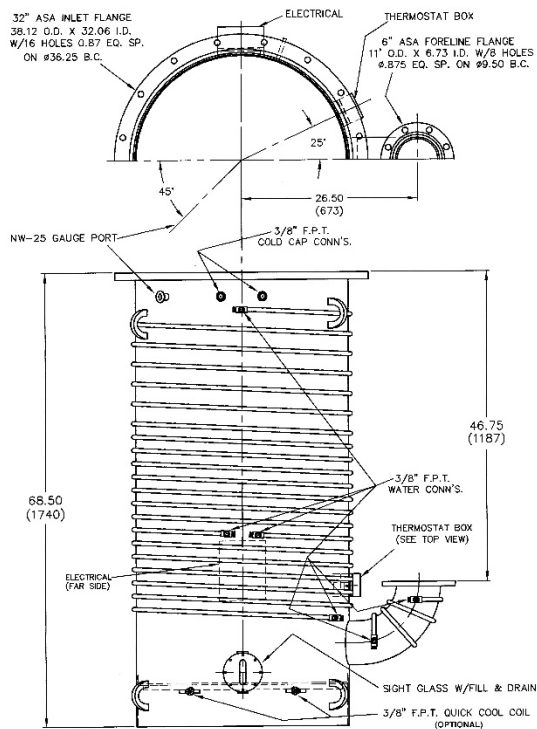


Table 9 HS-32: Dimensions and Weights

	Units	HS-32
Height, minimum including clearance for heater access	in (mm)	74 (1879.6)
Weight	lbs (kg)	1500 (680.4)
Connections:		
Body and Foreline	in	3/8 FPT
Quick Cool coils	in	3/8 FPT

Figure 9 HS-32 Outline with ASA Flanges

Table 10 HS-32 Flange Dimensions

		ASA		ISO	
		Units	Inlet	Foreline	
OD		in (mm)	38.12 (968.3)	11.00 (279.4)	36.22 (920.0)
ID		in (mm)	32.06 (814.3)	6.73 (170.9)	32.06 (814.3)
Thickness		in (mm)	1.12 (28.5)	0.75 (19.1)	1.12 (28.5)
Bolt Circle		in (mm)	36.25 (920.8)	9.50 (241.3)	35.04 (890.0)
No. of Holes			16	8	24
Size of Holes		in (mm)	0.87 (22.1)	0.88 (22.4)	0.55 (14.0)
Orientation			Holes straddle center line of foreline		
Gasket Groove	ID	in (mm)	32.5 (825.5)	7.44 (189.0)	32.75 (831.9)
	Width	in (mm)	0.56 (14.2)	0.38 (9.7)	0.56 (14.2)
	Depth	in (mm)	0.25 (6.4)	0.18 (4.6)	0.25 (6.35)

Technical Information

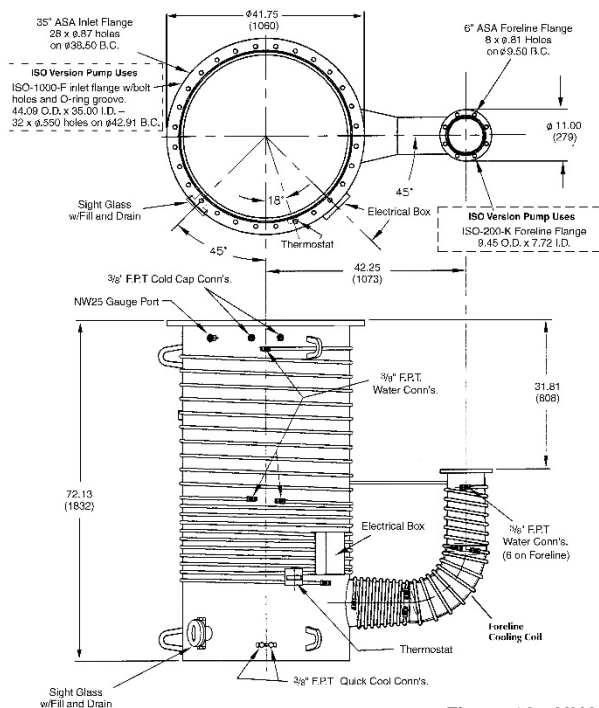


Table 11 NHS-35: Dimensions and Weights

	Units	NHS-35
Height, minimum including clearance for heater access	in (mm)	80 (2032)
Weight	lbs (kg)	1500 (680.4)
Connections:		
Body and Foreline	in	3/8 FPT
Quick Cool coils	in	3/8 FPT

Figure 10 NHS-35 Outline with ASA Flanges

Table 12 NHS-35 Flange Dimensions

			ASA		ISO	
			Inlet	Foreline	Inlet, 1000 F	Foreline, 200 K
OD	in (mm)		41.75 (1060.5)	11.00 (279.4)	44.09 (1119.9)	9.45 (240.0)
ID	in (mm)		35.00 (889.0)	7.72 (196.1)	35.00 (889.0)	7.72 (196.1)
Thickness	in (mm)		1.12 (28.5)	0.75 (19.1)	1.12 (28.5)	0.47 (12.0)
Bolt Circle	in (mm)		38.50 (977.9)	9.50 (241.3)	42.90 (1089.7)	
No. of Holes			28	8	32	
Size of Holes	in (mm)		0.87 (22.1)	0.81 (20.6)	0.55 (14.0)	
Orientation			Holes straddles center line of foreline			
Gasket Groove	ID	in (mm)	35.37 (898.4)	8.20 (208.3)	40.75 (1035.1)	Requires NW-200 Centering Ring (not included with pump)
	Width	in (mm)	0.56 (14.2)	0.17 (4.3)	0.56 (14.2)	
	Depth	in (mm)	0.25 (6.4)	0.09 (2.3)	0.25 (6.4)	

Unpacking

WARNING



- Before lifting a pump, check the weight of the equipment in Table 4.
- Use power-assisted equipment, and trained moving and installation personnel to avoid dropping, slipping, and overturning the pump and severely injuring personnel.
- Do not stand under equipment being moved.

Agilent large diffusion pumps are shipped in sturdy containers that permit prolonged storage in suitably protected areas without special precautions, however, care must be taken when moving the crated pump with a fork lift to avoid excessive shock.

Carefully remove the outer shipping container. Visually inspect the pump for damage that may have occurred during shipping and notify the carrier immediately if damage is suspected. If damage is noticed, save the crate and the internal packing for inspection.

Setup

Assembly

- 1 Remove flange covers, blank plugs and protective plugs from water connections. Do not to scratch or otherwise damage the sealing surface (the O-ring groove on top of the inlet flange).
- 2 Check the internal jet assembly. It should be concentric and firmly seated on the bottom of the pump. Use a flashlight to verify that the ejector nozzle is opposite the foreline (the pump outlet connection). The jet assembly should not rotate; it is held by an indexing pin at the bottom of the assembly.
- 3 If the expected vacuum level is below 10^{-7} Torr, clean the pump using the procedure outlined in the next section. Otherwise make sure that there are no foreign materials inside the pump, and proceed with attaching the pump to the system as instructed in "System and Utility Connections".

Cleaning a New Pump

NOTE

A new pump requires cleaning only if the desired vacuum is below 1×10^{-7} Torr.

Cleaning Safety

Cleaning a diffusion pump involves the use of acetone and alcohol, both of which are toxic and explosive. Take careful note of the following information and warnings before starting a cleaning process.

When heated, sprayed or exposed to high temperature equipment, these solvents become flammable and explosive, causing serious injury or death.

When heated or sprayed, acetone or alcohol also becomes 4 to 5 times heavier than air and flows down, settling in tanks, pits, and low areas, displacing air, and thus, can kill by asphyxiation.

Acetone, alcohol, and other solvents are irritants, narcotics, depressants, and carcinogenic. Their inhalation and ingestion may produce serious effects. Prolonged or continued contact with the skin will result in absorption through the skin and moderate toxicity.

WARNING



- **Do not use near a high temperature source.**
- **Always use in a large, well-ventilated room and ventilate the working area with a blower.**
- **Wear eyeshields, gloves, and other protective clothing. The use of a self-contained breathing apparatus may also be necessary.**

Disassembly for Initial Cleaning

This procedure involves the cleaning of the following elements:

- Jet assembly
- Drain plugs
- Sight glass
- Pump interior

To disassemble the pump:

- 1 Remove the cold cap as described in “Cold Cap”.
- 2 Disassemble the internal jet system from the body of the pump in accordance with the appropriate procedure within “Jet Assemblies”.
- 3 Remove fill and drain plugs and the sight glass with its O-ring and graphite gasket.

Set the O-ring aside as it must not be cleaned with a strong solvent. Alcohol, acetone, and other solvents degrade O-ring materials reducing their ability to hold a vacuum. If it is necessary to clean any O-rings, wipe with lint-free, clean cloth, wash in detergent and water, or use a small amount of pump fluid.

CAUTION

Do not use any solvents on O-rings.

- 4 Thoroughly clean all components of the jet assembly and pump casing interior (but not O-rings) with acetone followed by an alcohol rinse.
- 5 Remove all traces of cleaning fluid by carefully drying all components with clean, dry, oil-free compressed air.

Reassembly After Initial Cleaning

To reassemble the pump:

- 1 Perform disassembly steps 1 to 3 in reverse order, then continue with the following steps on a cleaned, reassembled pump.
- 2 Clean the interface and inlet flanges and O-ring grooves thoroughly with acetone or alcohol, using clean, lint free rags.
- 3 Remove all traces of acetone and alcohol by carefully drying all components, particularly the O-ring grooves, with clean, dry, oil-free compressed air.
- 4 Re-install the O-ring gasket.

System and Utility Connections

WARNING



Utility failure can cause overheating, damage to the equipment and explosion. Design your system to protect personnel and property from these hazards.

Vacuum Connections

The pump body must be installed vertical and plumb. Check that the mating flange on the system is horizontal $\pm 1^\circ$. If this condition is not met, correct the system mount before installing the pump.

To make the vacuum system connection:

- 1** Wipe the O-ring seals with a clean cloth lightly moistened with diffusion pump fluid. Do not use solvents.
- 2** Install the O-ring in its groove. Be careful not to damage the sealing surface with cuts, nicks, or scratches.
- 3** Raise the pump using a lifting apparatus with sufficient capacity. Pump weights are given in Table 4.
- 4** Align the bolt holes of the flanges and assemble the bolts.
- 5** Tighten the bolts evenly and compress the O-ring seal until light contact is achieved between the metal flanges.
- 6** Make a tightness check of the fill and drain plugs and the sight glass assembly. Refer to the appropriate outline drawings, Figure 7 through Figure 10. Apply light to medium torque, just enough to visually compress the gaskets.

NOTE

Over time, minute leaks may develop through the gaskets. These leaks may only be detectable with extremely sensitive mass spectrometer leak detectors.

Cooling Water

To connect cooling water HS-16/20:

- 1 Connect the cold cap cooling coil and all body and foreline cooling in series except the Quick Cool coil (see the following paragraph) as shown in Figure 11. Refer to Table 4 for the cooling water flowrate for your pump type. Higher flows will not harm the pump.
- 2 If the diffusion pump is being cooled by a recirculating water system, ensure the system is capable of:
 - Adequate cooling and heat exchange to ensure a continuous inlet temperature of 60 to 80 °F (16 to 27 °C).
 - Maintaining an adequate flow rate to ensure the exit water temperature does not exceed 130 °F (54 °C).

Parallel connections should be employed when the water pressure is low or if the discharge temperature routinely exceeds 130 °F.

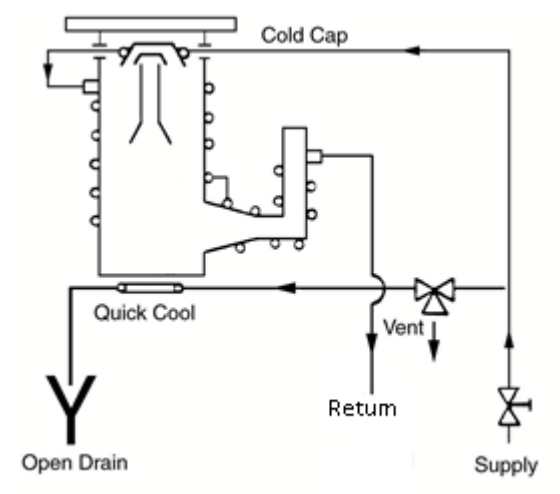


Figure 11 HS-16/20 Cooling Water Connections

Technical Information

To connect cooling water HS-32/NHS-35:

- 1 Connect all body and foreline cooling in series except the Quick Cool coil. Connect the Cold Cap cooling coil separately (Figure 12). Refer to Table 4 for the cooling water flow rate. Higher flows will not harm the pump.
- 2 If the diffusion pump is being cooled by a recirculating water system, ensure the system is capable of:
 - Adequate cooling and heat exchange to ensure a continuous inlet temperature of 60 to 80 °F (16 to 27 °C).
 - Maintaining an adequate flow rate to ensure the exit water temperature does not exceed 130 °F (54 °C).

Parallel connections should be employed when the water pressure is low or if the discharge temperature from the pump body routinely exceeds 130 °F (54 °C).

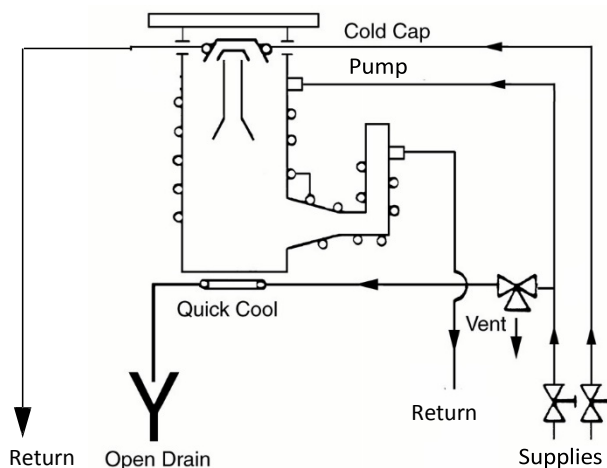


Figure 12 HS-32/NHS-35 Cooling Water Connections

Quick Cool Coil Connection

The Quick Cool coil at the boiler plate must be connected to an open drain and the feed line must be controlled by a separate water 3-way valve: open, closed, and vented to the atmosphere. The drain must be below the boiler level so that it is drained completely when the Quick Cool coil water supply is shut off and the pump is operating.

Obtaining High Vacuum on the NHS-35

When operating at low pressures (below 1×10^{-6} Torr), the ultimate pressure can be lowered by bypassing the portion of the cooling coils located at the bend of the foreline as shown in Figure 10. This procedure raises the temperature of the foreline and provides additional degassing of the fluid returning to the boiler, thus making lower pressures possible.

NOTE

This configuration decreases the maximum throughput capacity of the pump. Use this cooling configuration only if the pump is not meant to operate near the high pressure end of its operating range.

Electrical Connections

Terminal connections for each pump are different depending on the source voltage available, the principle difference being a Y or Δ connection of the heaters. The following Table provides the figure number and page of the wiring diagrams in this manual. The specific wiring diagrams for each pump shows both Y and Δ connections and the source voltages for each connection.

WARNING



Improper operation, severe heater damage, and danger to personnel can result from an improperly wired diffusion pump system.

WARNING



High voltages (up to 480 V) can kill.

Always break the primary circuit to the pump before starting work on the heater or its wiring.

Table 13 Wiring Diagram Locations

Source Voltage	HS-16 Wiring	HS-20 Wiring	HS-32 Wiring	NHS-35 Wiring
200 Delta		Figure 15		
208 Delta	Figure 13	Figure 15		
220 Delta		Figure 15	Figure 17	Figure 20
240 Delta	Figure 13	Figure 15	Figure 17	Figure 20
265 Delta		Figure 15		
380 Delta	Figure 13	Figure 15		Figure 20
380 Wye		Figure 16		
400 Delta	Figure 13	Figure 15	Figure 17	
415 Wye	Figure 14	Figure 16	Figure 18	Figure 21
430 Delta	Figure 13	Figure 15		
440 Delta	Figure 13	Figure 15	Figure 17	
460 Delta	Figure 13	Figure 15		Figure 20
480 Delta	Figure 13	Figure 15	Figure 19	Figure 22
575 Delta	Figure 13	Figure 15		

CAUTION

Do not operate the pump at more than 5% over its rated voltage.

All electrical connections must be made by qualified personnel in accordance with all applicable laws and industrial codes.

For overcurrent protection, the pump must be installed with appropriate branch circuit protection.

To guarantee electrical safety, ensure the diffusion pump is bonded to the earth ground system.

The pump must be installed in an installation that meets the pumps operating environment.

The end user must ensure the product has a connection from a correctly sized roughing pump on the diffusion pump's vacuum inlet, and that the end product has an appropriately sized and certified mains voltage disconnecting device and/or mains power switch.

Technical Information

To wire the pump:

- 1** Check the heater for correct supply voltage and find the appropriate wiring diagram. The correct voltage is shown.
- 2** Check load balance by measuring the resistance of each branch. The heater resistances are given on their respective wiring diagrams.
- 3** Make the connections to the terminals in the electrical main junction box at the foreline shown in the appropriate outline drawing. Use flexible conduit to make it easier to remove the pump for service.
- 4** Connect the earth ground wire directly to the aluminum set screw ground lug.
- 5** Connect the input wires to the terminal block positions L1, L2 and L3 (& N). For added safety, to prevent the wires from being disconnected, secure these wires together with the earth ground wire inside the junction box with a tie-wrap, similar to what has been done with the heater wires.
- 6** Wire the thermal switches to a control mechanism to ensure that power to the pump is shut off if one of the switches opens. The thermal switch wires can be found in the electrical box.
- 7** Complete the wiring of the pump and double-check that the proper terminal arrangement has been used for the source voltage at the site.

Overheating: Detection by Thermal Switches

An overheat condition is detected by two normally closed thermal cutout switches, one of which monitors the boiler temperature while the other monitors the water temperature. These switches are set at the factory and do not require adjustment. The cutout temperatures for the water and boiler switches are given in the following table.

Table 14 Thermal Cutout Temperatures

	Units	HS-16	HS-20	HS-32	NHS-35
Water Switch	°F	185	185	220	200
Boiler Switch	°F	390	390	550	600

Wire the pump such that if the contacts open on either the boiler or the water switch, power to the pump shuts off. If this happens during operation, check for one of the failure conditions listed below. When the problem has been corrected and the temperature lowered, the thermal switch automatically resets.

A rise in pump temperature can be caused by:

- Failure of cooling water flow
- High inlet pressure
- Low fluid level in the boiler

If you determine that the pump has not overheated and that the thermal switch has failed or drifted out of calibration, replace the switch with the device listed for your pump type in the appropriate Replacement Parts table.

CAUTION

Thermal switches set to measure the temperature in the diffusion pump fluid are not designed to protect against overheating or backstreamed mechanical pump fluids.

Technical Information

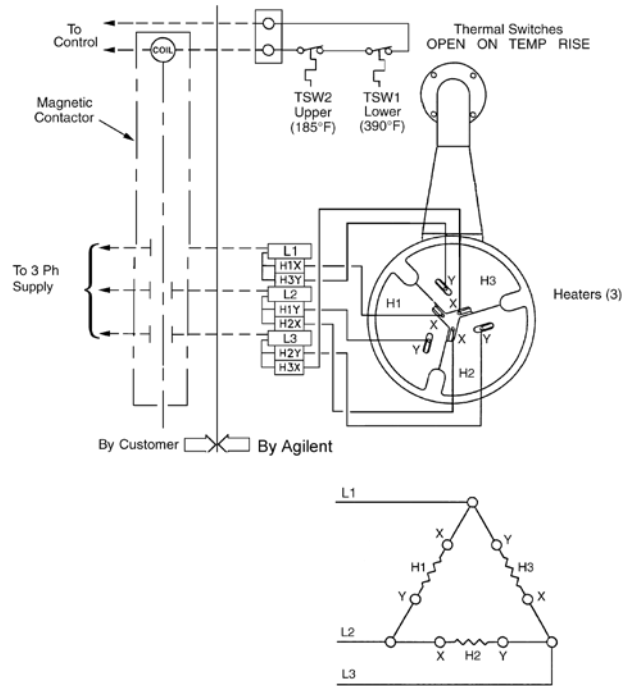


Figure 13 HS-16 3-Phase Delta Circuit

Table 15 HS-16 3 Phase Delta

NORMINAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)		LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1		LINE CURRENT (AMPS)	
2700 W	3200 W	8100 WATTS	9600 WATTS	8100 WATTS	9600 WATTS
N/A	208 V = 12.8	N/A	208 V = 8.6	N/A	26.6
240 V = 20.3	240 V = 17.1	240V = 13.5	240 V = 11.4	19.5	23.1
380 V = 50.1	380 V = 45.1	380 V = 33.9	380 V = 28.6	12.3	14.6
400 V = 56.3	400 V = 47.5	400 V = 37.5	400 V = 31.7	11.7	13.9
430 V = 65.1	N/A	430 V = 43.4	N/A	10.9	N/A
440 V = 68.1	440 V = 57.5	440 V = 45.4	440 V = 38.3	10.6	12.6
460 V = 74.5	N/A	460 V = 49.6	N/A	10.2	N/A
480 V = 81.1	480 V = 68.4	480 V = 54.0	480 V = 45.6	9.7	11.6
N/A	575 V = 98.2	N/A	575 V = 65.4	N/A	9.6

Technical Information

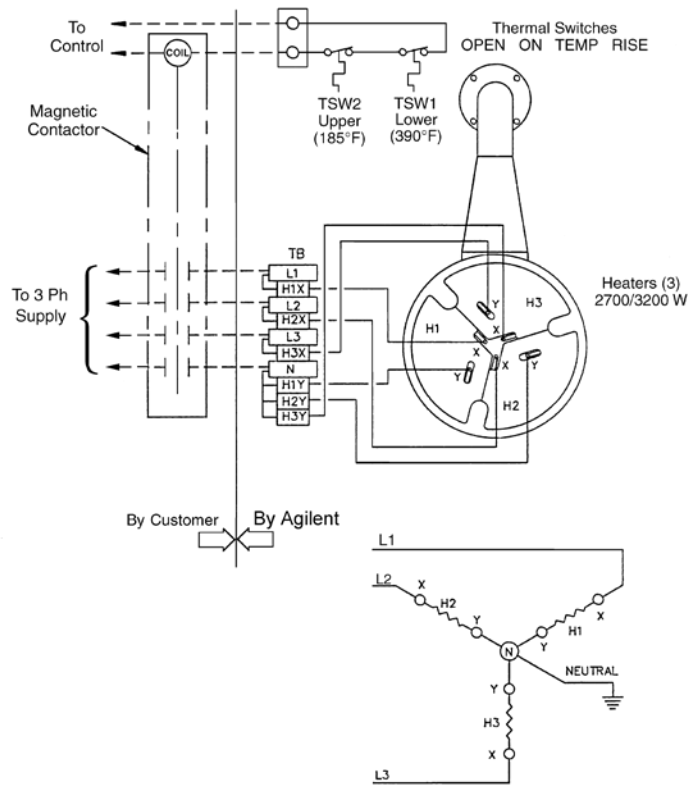


Figure 14 HS-16 3-Phase WYE Circuit

Table 16 HS-16 3 Phase WYE

NORMINAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)		LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1		LINE CURRENT (AMPS)	
2700 W	3200 W	8100 WATTS	9600 WATTS	8100 WATTS	9600 WATTS
240 V = 20.3	240 V = 17.1	415 V = 40.4	415 V = 34.1	11.3	13.4

Technical Information

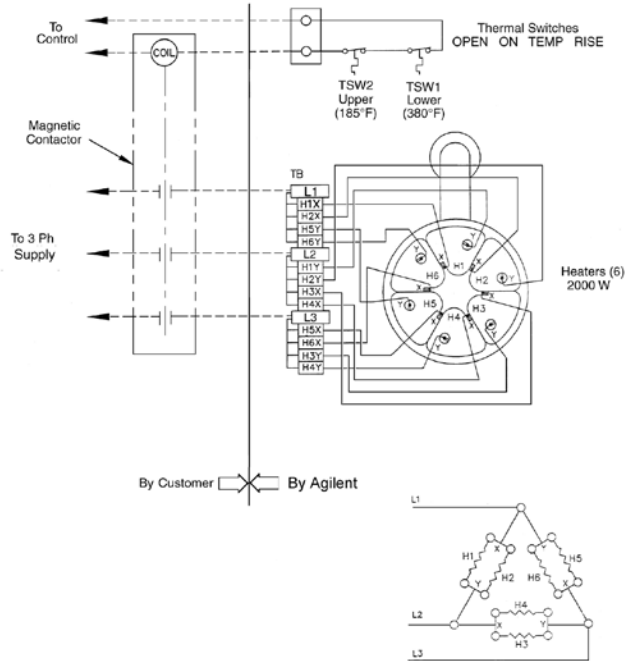


Figure 15 HS-20 3-Phase Delta Parallel Circuit

Table 17 HS-20 3-Phase Delta Parallel

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
2000 W	12000 Watts	12000 Watts
200 V = 19	200 V = 6.3	34.6
208 V = 20.5	208 V = 6.8	33.3
220 V = 22.9	220 V = 8.1	31.5
240 V = 27.3	240 V = 9.1	28.9
265 V = 33.3	265 V = 11.1	26.1
380 V = 68.5	380 V = 22.8	18.2
400 V = 75.8	400 V = 25.3	17.3
420 V = 83.6	420 V = 27.8	16.5
430 V = 87.6	430 V = 29.2	16.1
440 V = 91.8	440 V = 30.6	15.8
460 V = 100.3	460 V = 33.4	15.1
480 V = 109.2	480 V = 36.4	14.4
575 V = 156.7	575 V = 52.2	12.1

Technical Information

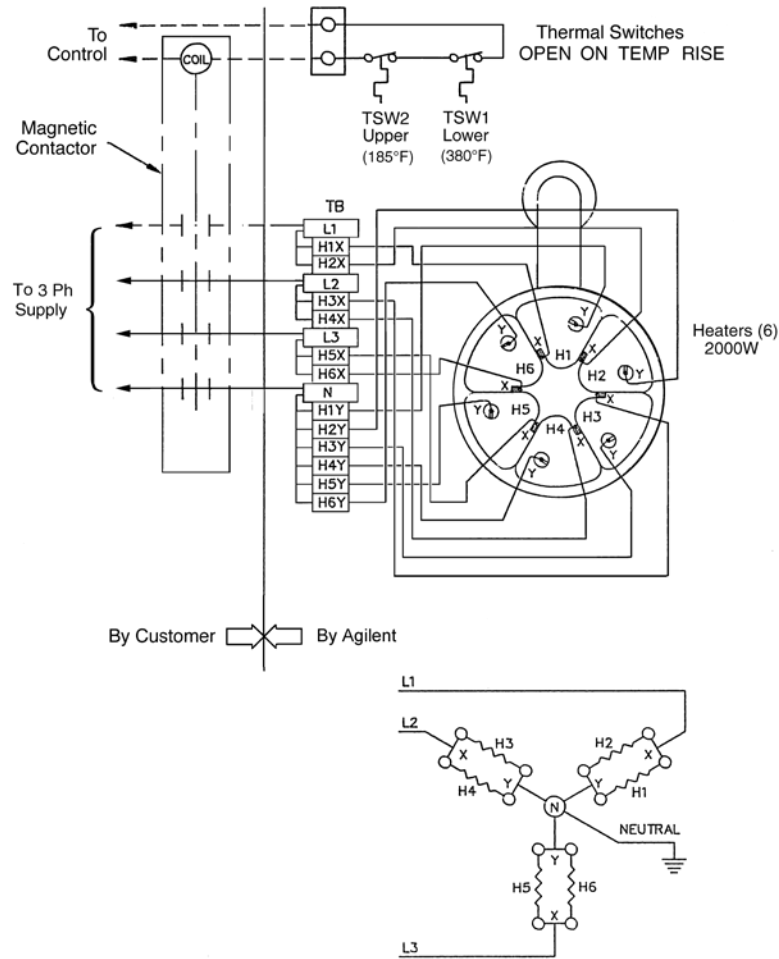


Figure 16 HS-20 3-Phase WYE Parallel Circuit

Table 18 HS-20 3-Phase WYE Parallel

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
2000 W	12000 Watts	12000 Watts
220 V = 22.9	380 V = 22.8	18.2
240 V = 27.3	415 v = 27.2	16.7

Technical Information

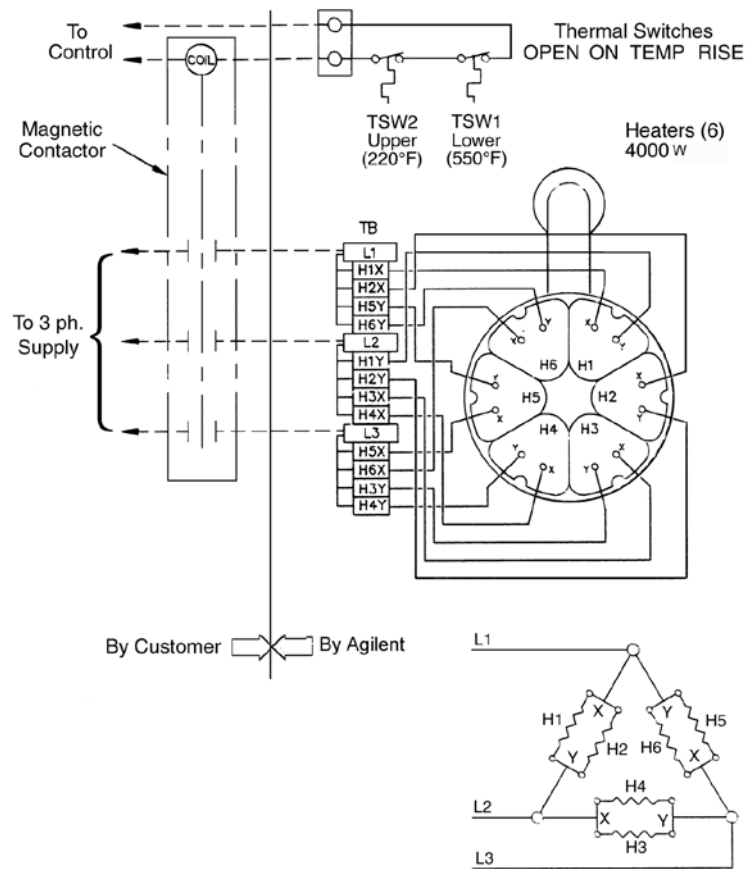


Figure 17 HS-32 3-Phase Delta Parallel Circuit

Table 19 HS-32 3-Phase Delta Parallel

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
4000 W	24000 Watts	24000 Watts
220 V = 11.5	220 V = 3.8	63
240 V = 13.7	240 V = 4.5	57.7
400 V = 37.9	400 V = 12.6	34.6
440 V = 45.9	440 V = 15.3	31.5
	480 V = 18.2	28.9

Technical Information

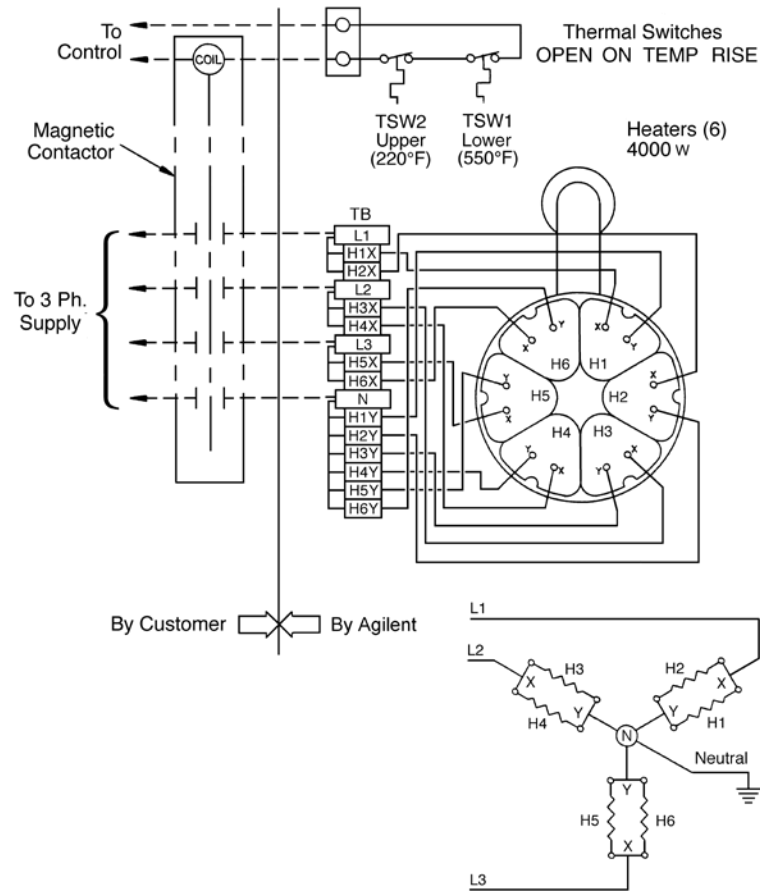


Figure 18 HS-32 3-Phase WYE Parallel Circuit

Table 20 HS-32 3-Phase WYE Parallel

NORMINAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
4000 W	24000 Watts	24000 Watts
240 V = 13.7	415 V = 13.6	33.4

Technical Information

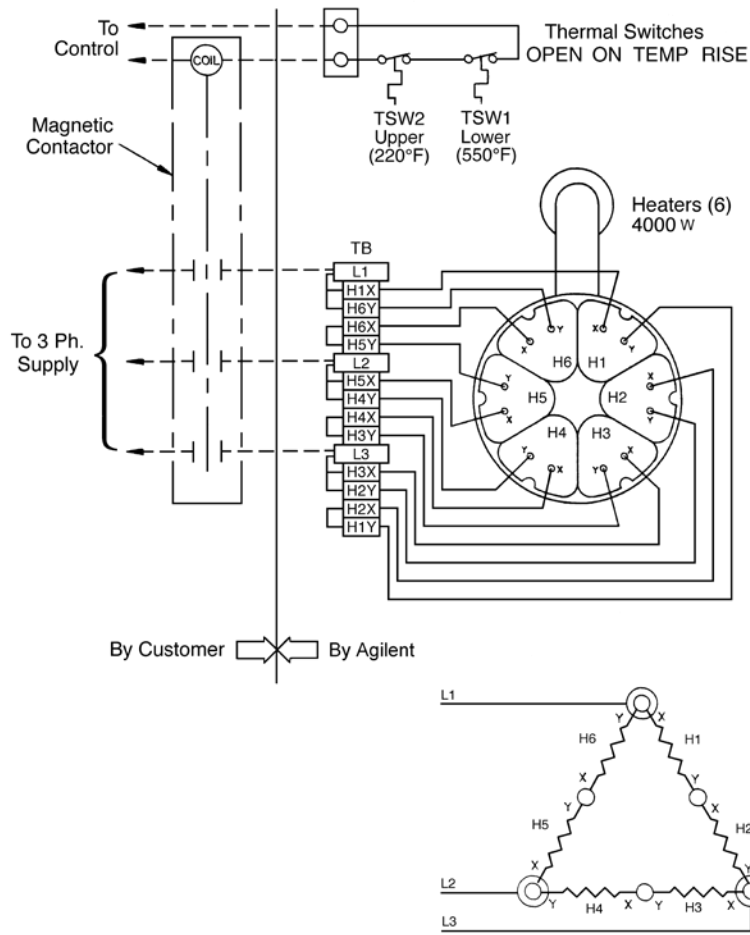


Figure 19 HS-32 3-Phase Delta Series Circuit

Table 21 HS-32 3-Phase Delta Series

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
4000 W	24000 Watts	24000 Watts
240 V = 13.7	480 V = 18.2	28.9

Technical Information

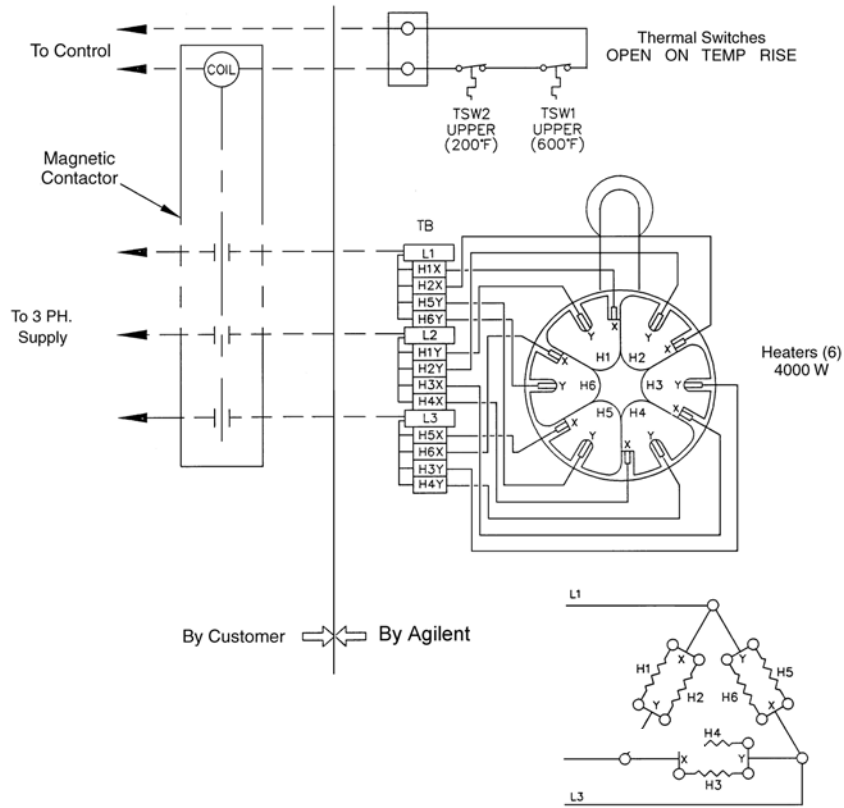


Figure 20 NHS-35 3-Phase Delta Parallel Circuit

Table 22 NHS-35 3-Phase Delta Parallel

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
4000 W	24000 Watts	24000 Watts
220 V = 11.5	220 V = 3.8	63
240 V = 13.7	240 V = 4.5	57.7
380 V = 34.2	380 V = 11.4	36.5
460 V = 37.9	460 V = 16.8	30.1
	480 V = 18.2	28.9

Technical Information

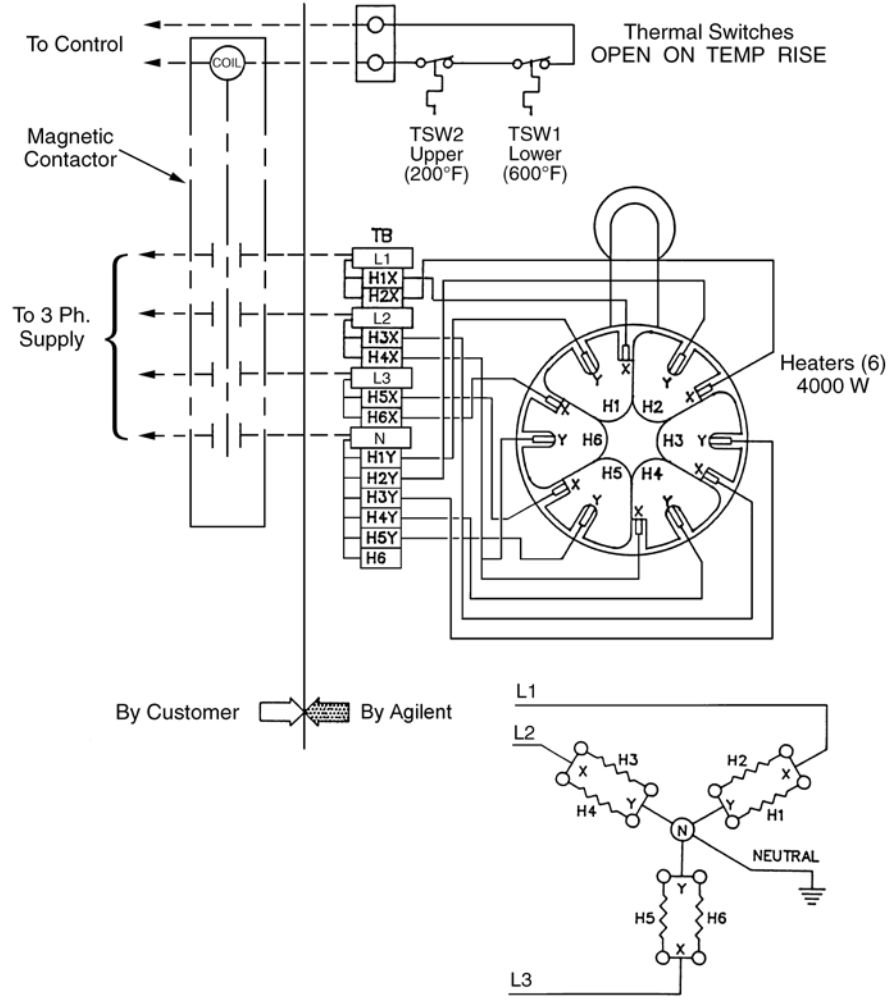


Figure 21 NHS-35 3-Phase WYE Parallel Circuit

Table 23 NHS-35 3-Phase WYE Parallel

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
4000 W	24000 Watts	24000 Watts
240 V = 13.7	415 V = 13.6	33.4

Technical Information

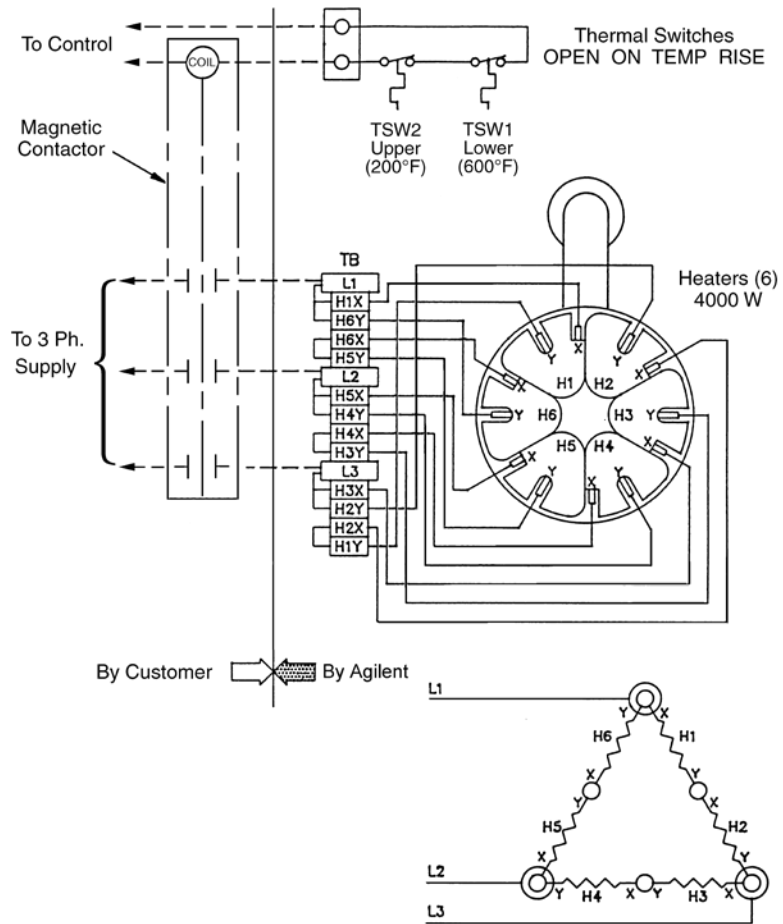


Figure 22 NHS-35 3-Phase Delta Series Circuit

Table 24 NHS-35 3-Phase Delta Series

NORMAL HEATER RESISTANCE @ ROOM TEMPERATURE (OHMS)	LINE TO LINE RESISTANCE (OHMS) L1-L2/L2-L3/L3-L1	LINE CURRENT (AMPS)
4000 W	24000 Watts	24000 Watts
240 V = 13.7	480 V = 18.2	28.9

Initial Vacuum Test

Before charging the pump with fluid, carry out this initial vacuum test to establish the tightness of the system and its vacuum connections.

Pumps and their components are designed for vacuum service; they are not designed to be pressurized which could cause them to burst possibly expelling shrapnel at lethal velocities. Serious accidents have been caused by intentional pressurization of vacuum systems and their components.

WARNING



- **Never pressurize any part of a vacuum system for test or any other purpose.**
- **Always provide pressure relief when designing diffusion pumps into systems and ensure that pressure relief motion is limited to safe envelopes.**

To perform the initial vacuum test:

- 1 Confirm the vacuum ultimate pressure characteristics of the fore pump. This should closely approximate the value quoted in the manufacturer's data, if the mechanical pump is correctly installed, adjusted, and filled with clean fluid.
 - 2 Measure pressure with a continuously indicating total pressure gauge, such as a capacitance manometer, or thermocouple gauge.
 - 3 Connect the outlet (or foreline) of the diffusion pump to the inlet of the fore pump using vacuum-tight connections.
 - 4 The procedure varies for valved and unvalved systems.
 - For valved system: Close the roughing valve and main isolation valve ahead of the diffusion pump.
- For unvalved systems: Include the entire work chamber volume in the test.
- 5 Evacuate the system using only the fore pump. Let the pump reach an ultimate pressure in the system. This reading should approximate the value obtained in step 2 above (usually 10 to 50 microns, 0.013 mbar to 0.067 mbar).
 - 6 If the pump does not reach this level, examine the system for leakage following standard procedures for leak testing. These procedures depend on the type of vacuum gauges and leak detection equipment available.

NOTE

Consult with your Agilent representative for information on Agilent's extensive line of helium leak detectors.

Adding or Changing Pump Fluid

WARNING



The risk of explosion on large vacuum diffusion pumps is increased by these factors:

- Use of a hydrocarbon fluid as the pumping fluid. Hydrocarbon fluid is more prone to explosion than synthetic silicone-based fluid. If a hydrocarbon fluid is being used, check the entire system under vacuum before operating the pump.
- Low fluid levels in the pump which can lead to overheating. Low fluid levels develop because the charge gradually depletes during use. The pump, however, continues to operate normally and when the charge drops to 60% of initial level, the boiler temperature may begin to rise. If this takes place, the thermal switches open the heater circuits. For details, refer to “Overheating: Detection by Thermal Switches”.
- Overheated pump fluid that decomposes and becomes toxic. The toxic fluid residue may be on the dipstick used to check fluid level, so care must always be taken to assure personnel do not contact or ingest the fluid.
- Admission of atmospheric air during pump operation. Leakage of air into the system allows oxygen into the fluid vapor and increases the risk of explosion. If holding a vacuum is difficult, perform a leak test. Do not use the pump until the leak source is located and repaired.

The recommended fluid charge for each pump is given in Table 4.

Fluids must be stored in clean, tightly closed containers and should be clearly identified in accordance with their type. Do not mix pumping fluids of different types and origins. Generally, it is not a good idea to mix used and new fluid for a pump charge.

CAUTION

The use of Santovac® 5 Diffusion Pump Fluid is not recommended in these pumps, nor is the use of any hydrocarbon fluid.

Information on Fluid and DP Performance

The choice of fluid depends on the application. The most common type of fluid used in the market is a silicone based fluid, and all vacuum performance data in this manual was generated using a silicone based fluid called DC704. There are many fluids on the market that are equivalent to the DC704. The pump will operate with other types of oil, but the performance may be different. Since there are so many options, it is not possible to summarize and recommend them all.

Technical Information

To add or change pump fluid:

- 1 Locate the fill and drain fittings in the appropriate outline drawing. Refer to Figure 7 through Figure 10. The fittings have special Viton® elastomer sealed plugs.
- 2 Assure that the power to the heaters is off.

CAUTION

Wait until the pump has cooled then vent it to the atmosphere.

- 3 Remove the drain plug and drain fluid into a suitable sized container.

NOTE

Dispose of fluids in accordance with all appropriate regulations.

- 4 Remove the plug from the filling port of the pump and pour the fluid in up to the FULL COLD level on the sight glass as shown in the following figure. The fluid can also be poured in from the pump inlet or foreline.

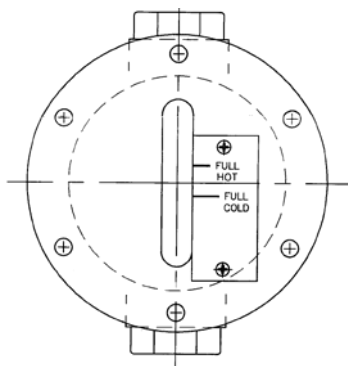


Figure 23 Sight Glass Assembly

- 5 Replace the fill plug with a new Viton gasket. Lubricate the O-ring with pump fluid, put the O-ring in place, and reassemble the system.
- 6 Tighten the fill plug using maximum torque of 75 inches-pounds.

Once the pump is running, check that the fluid level is at the FULL HOT level in the sight glass.

Operation

During initial installation, the newly installed pump fluid may be subjected to degassing. This may result in foreline pressure fluctuations that are considered normal.

WARNING



The following conditions increase the risk of explosion:

- Air leaks into the system
 - Roughing through a hot diffusion pump, which can cause hot hydrocarbon fluids to ignite or explode when exposed to air
 - Air release or the admission of air to a pump with a hot boiler (permitting a strong oxidizer to contact the hot pump fluid)
 - Pressure above 1 milliTorr (1.3×10^{-3} mbar)
 - Insufficient (or low level of) pump fluid
 - Operating a pump without circulating cool water to the main body cooling coils
 - Operating pump with water trapped in Quick Cool coil
 - Foreign matter in the pumping fluid, which changes its viscosity and obstructs flow passages.
-

CAUTION

- Do not turn on the heater without fluid in the pump. This may ruin the heaters and damage the pump.
 - Do not air-release the pump while the boiler is hot. Most diffusion pump fluids break down under these conditions.
 - Do not operate the pump heater unless cooling water is circulating. Doing so causes the pump and fluid to overheat.
 - Do not operate without a foreline baffle. This can cause a greater than normal fluid loss. *The HS-32 does not have a foreline baffle.
-

Startup Procedure

To start the pump:

- 1 Evacuate the diffusion pump using a mechanical roughing pump to below 0.5 Torr (0.67 mbar). The diffusion pump will not function unless the discharge pressure is less than the tolerable forepressure.
- 2 Turn on the cooling water supply to the pump body and check that adequate flow is provided by examining the amount of water discharged at the visual drain points

CAUTION

To prevent harmful collection of condensate on the boiler plate, heater, and heater terminals, do not operate the Quick Cool coil when the pump is cold or out of service.

- 3 Switch on the power to the diffusion pump heater.
- 4 Check inlet and forepressure performance by means of the system instrumentation.

Humid Environments

Due to their inherent design, diffusion pump heaters absorb moisture. This results in a decrease in heater insulation resistance (higher leakage current). Under normal conditions, the decrease in insulation resistance is a momentary condition that occurs on startup. The amount of moisture adsorbed depends on the temperature, humidity, and the length of time the heaters have been exposed to this environment without power being applied. If diffusion pumps are started in high humidity environments, the heaters may be damaged on startup at full power. To overcome the effect of moisture absorbed in the heaters, start pumps at a low line voltage, e.g., 50% of line voltage, for a period or time to slowly expel any moisture.

Shutdown Procedure

WARNING



- 1** Releasing or admitting air to a pump with a hot boiler, especially when it is under vacuum, permits a strong oxidizer to contact the hot pump fluid and greatly increases the risk of an explosion.
- 2** Boiler temperatures reach 530° F (275 °C) which can cause serious burns. Always check that surfaces have cooled to near room temperature before touching them.

To shut down the pump:

- 1** Close the inlet valve on the system, if equipped.
- 2** Turn off the power to the heaters.
- 3** For pumps equipped with the optional Quick Cool Coil, admit water into the coil.
- 4** Continue to flow cooling water through the pump (and Quick Cool Coil, if equipped) for at least the time period listed under "Cooldown Time Without Quick Cool With Quick Cool" in Table 4.
- 5** Once the pump is cooled, shut off the mechanical backing pump.
- 6** Air release the pump.
- 7** Continue cooling water flow until the pump is at room temperature, then shut off the water supply.

Maintenance

Perform these periodic checks to assure trouble-free operation. This maintenance prevents costly down-time and cleaning procedures. Maintain a day-to-day log of pump and system performance to identify marked variations that require corrective action.

Periodic Inspections

The maximum interval between inspection of the pump is established on the basis of experience.

WARNING



- **High voltages (up to 480 V) can kill. Always break the primary circuit to the power supply before starting work on the heater or its wiring.**
- **Avoid the possibility of serious burns by making sure that the pump is at room temperature before attempting service.**
- **Always wear appropriate gloves and clothing and use a self-contained breathing apparatus. Poisonous or corrosive compounds may be present when opening the fill or drain.**
- **Explosion risk is high if the fill or drain is opened when the pump is running or when it is hot.**

To perform general maintenance, do the following:

- 1 Check the condition and level of fluid when the pump is cold. Withdraw a sample through the drain and visually check the level of fluid through the sight glass. Slight discoloration of the fluid does not affect pump performance. Use new O-ring gaskets when replacing fill and drain plugs. Loss of the fluid can be caused by.
 - Admittance of excessive air or other gas to a hot pump
 - Inadequate water cooling
 - Continuous operation in the overload range as given in Table 4
 - Failure to reinsert the foreline baffle in the pump assembly.

NOTE

The HS-32 does not have a foreline baffle.

- 2 When the pump is cold, check that the heaters are bolted snugly to the boiler plate and that all heater terminal connections are fastened tightly inside the junction box.
- 3 Check the total heater power input and balance of the load.
- 4 Ensure that cooling water flow is unobstructed and that the flow rate does not fall not below quantities specified in Table 4.

Cleaning

Cleaning Safety

Cleaning a diffusion pump involves the use of acetone and alcohol, both of which are toxic and explosive. Take careful note of the following warnings before starting a cleaning process.

When heated, sprayed or exposed to high temperature equipment, these solvents become flammable and explosive, causing serious injury or death.

When heated or sprayed, acetone or alcohol also becomes 4 to 5 times heavier than air and will flow down, settling in tanks, pits, and low areas, thus displacing air which can kill by asphyxiation.

Acetone, alcohol, and other solvents are irritants, narcotics, depressants, and carcinogenic. Their inhalation and ingestion may produce serious effects. Prolonged or continued contact with the skin will result in absorption through the skin and moderate toxicity.

WARNING



- Do not use near a high temperature source. Ventilate the working area with a blower and use in a large, well-ventilated room. The use of a self-contained breathing apparatus may also be necessary.
- Always ensure that cleaning operations are carried out in large, well-ventilated rooms. Wear eyeshields, gloves, and protective clothing.

Technical Information

Complete cleaning of the pump may be required due to gradual deterioration of pump fluids. Removal of the pump from the system is then necessary.

To clean an installed pump:

- 1** Disconnect all water cooling lines and break the primary circuit supplying power to the pump heaters.
- 2** Unbolt the inlet and foreline connections and remove the pump from the system.
- 3** Drain the pump of all fluid.
- 4** Remove the cold cap as described in "Cold Cap".
- 5** Remove the jet assembly as described for the specific pump model in "Jet Assemblies".
- 6** Thoroughly clean the pump body interior using acetone followed by an isopropyl alcohol rinse and then dry the pump with clean, dry, oil-free compressed air.
- 7** Thoroughly clean the jet assembly using acetone. Wipe all surfaces with isopropyl alcohol, and dry with clean, dry, oil-free compressed air.
- 8** Reinstall the jet and cold cap in the pump body. Be sure that the ejector is properly aligned with the foreline.
- 9** Check the condition of the O-rings. Replace O-rings that show any sign of wear or compression.
- 10** Attach the pump in the system.

Disassembly and Reassembly Procedures

Cold Cap

To disassemble the cold cap, refer to the following figure and take the following steps.

NOTE

The halo baffle is disassembled in the same manner.

- 1 Remove the female coupling, nut, follower, and gasket located at the end of the cold cap water line on the outside of the pump.
- 2 Remove the cold cap securing screw which secures the cold cap to the jet assembly.
- 3 Lift out the cold cap.

To reassemble the cold cap:

- 1 Insert the end of the cold cap water line into the cold cap port opening at the side of the pump before setting the cold cap on top of the jet assembly. Be careful not to damage the sealing surfaces.
- 2 Replace the cold cap securing screw which secures the cold cap to the jet assembly. Do not overtighten the screw.
- 3 Replace the gasket, the follower, the nut, and the female coupling to the side of the pump.

Technical Information

NOTE

Supply water tubing must be connected to the cold cap coupling with FPT threads.

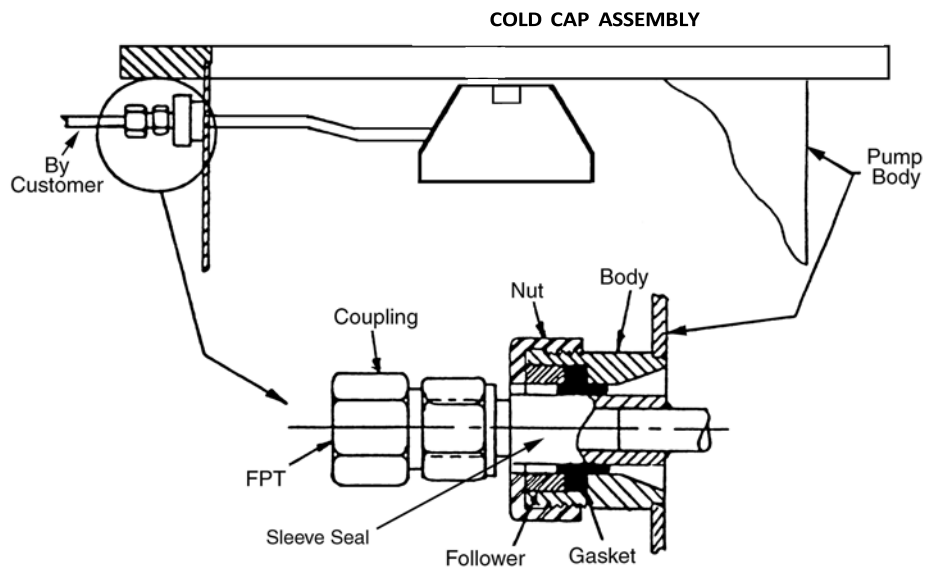


Figure 24 Cold Cap Assembly

Jet Assemblies

The jet assemblies of each of the pumps are discussed and shown in the following subsections. Procedures and drawings are specific to each pump model.

HS-16 Jet Assembly

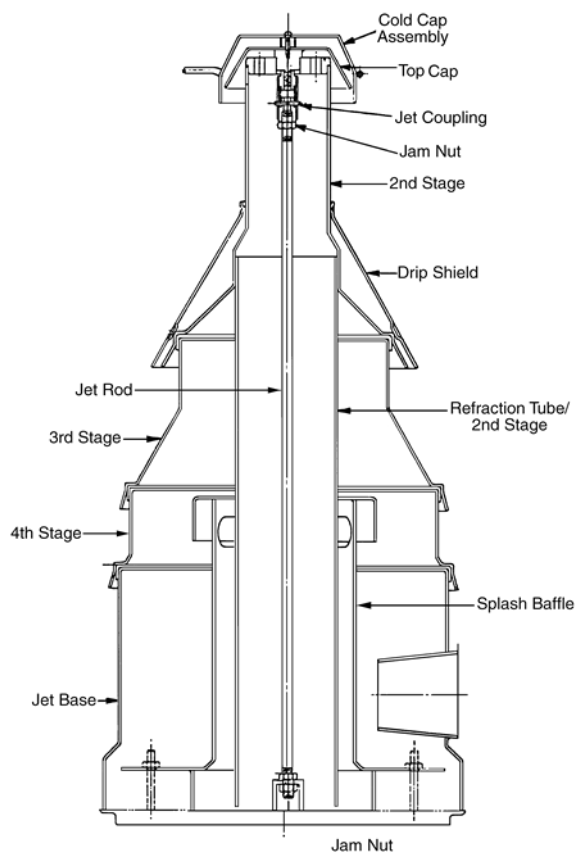


Figure 25 HS-16 Jet Assembly

Technical Information

To disassemble the jet assembly:

- 1** Remove the cold cap or halo baffle as described in "Cold Cap".
- 2** Unscrew the top cap from its coupling and remove it.
- 3** Remove the top plug.
- 4** Remove the drip shield that sits loosely on the 2nd stage.
- 5** Lift and remove the entire 2nd stage.
- 6** Lift and individually remove the 3rd stage, the 4th stage, and the jet base.
- 7** Remove the two nuts securing the splash baffle, then lift and remove the splash baffle.
- 8** Remove the jam nut located at the center-bottom of the pump in order to remove the jet rod.

To assemble the jet assembly:

- Reverse the disassembly steps above.

NOTE

When the jet assembly is installed in the pump body, be sure that the slot in the jet base is engaged in the locating pin of the boiler. Unless this is done, the pump will not function properly.

NOTE

If the jet coupling loosens from the jet rod during disassembly, position it so that the top of the jet coupling is flush with the bottom orifice plug as can be seen in Figure 27.

HS-20 Jet Assembly

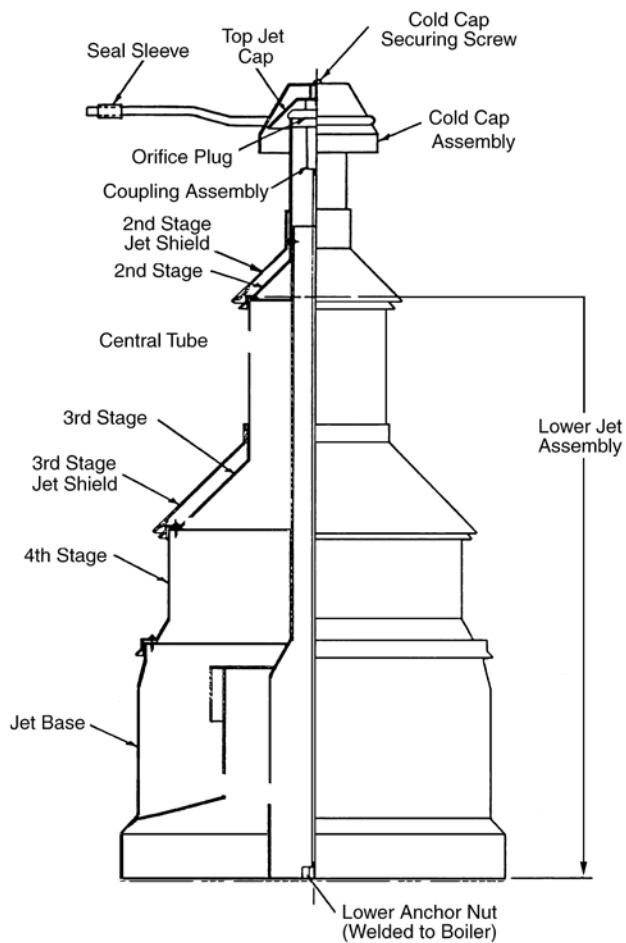


Figure 26 HS-20 Jet Assembly

Technical Information

To disassemble the jet assembly:

- 1 Remove the cold cap or halo baffle as described in "Cold Cap".
- 2 Unscrew the jet cap from the coupling assembly.
- 3 Remove the orifice plug.
- 4 Withdraw the central tube complete with the second stage jet and jet shield.
- 5 Remove the lower jet assembly from the pump, which consists of the third stage jet, the jet shield, the fourth stage jet, and the jet base.
- 6 Remove the third stage shield from the lower jet assembly.

NOTE

Before removing the securing screws in the following step, scribe a reference mark at the interface to assure that original holes are mated when reassembled.

- 7 Remove the securing screws between the third and fourth stage jets. Carefully preserve the screws. Be sure that the jet spacers are not damaged in handling.
- 8 Remove the fourth stage jet from the jet base.
- 9 Clean all parts thoroughly.

To reassemble the jet assembly:

- 1 Replace the fourth stage jet on the jet base.
- 2 Replace and tighten the securing screws between the fourth stage and the jet base uniformly and in a cyclical pattern.

NOTE

Jet spacings are preset at the factory and controlled by the spacers secured to the respective stages.

- 3 Replace the third stage jet on the fourth stage.
- 4 Replace and tighten the securing screws between the third stage and fourth stage uniformly and in a cyclical pattern.
- 5 Replace the third stage jet shield.
- 6 Install the lower jet assembly in the pump.
- 7 Check that the lower jet assembly is firmly seated on the pump with the ejector correctly positioned. For proper alignment, a pin is provided in the base of the pump; the large slot in the jet base must register on this pin.

Technical Information

- 8 Follow steps 1 through 5 in reverse order.

NOTE

If the jet coupling loosens from the jet rod during disassembly, position it so that the top of the jet coupling is flush with the bottom orifice plug (Figure 27).

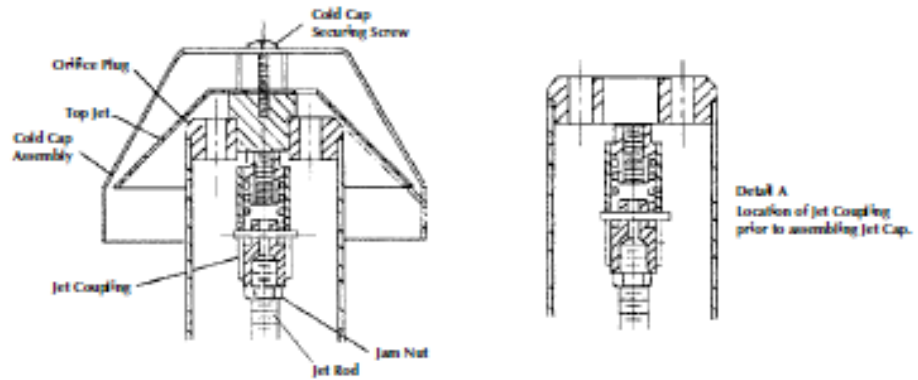


Figure 27 Jet Coupling Detail

HS-32 Jet Assembly

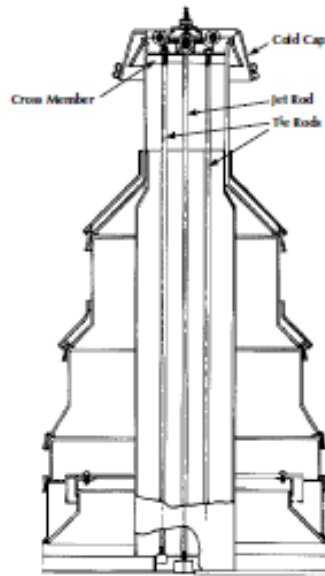


Figure 28 HS-32 Jet Assembly

To disassemble the jet:

- 1** Unscrew and remove the hex nut holding the cold cap in place. Note its orientation prior to removal.
- 2** Remove the cold cap (or halo baffle) as described in "Cold Cap".
- 3** Remove the nut, washer, and the top jet cap from the center jet rod.
- 4** Using the now-exposed cross member and the appropriate lifting equipment, lift the entire jet assembly out of the pump body, leaving the jet rod in place.
- 5** Remove the second stage jet shield.
- 6** Remove the two nuts on the cross member and lift out the second stage and fractionating tub, leaving the two rods in place.
- 7** Unscrew and remove the two tie rods.
- 8** Disassemble the remaining jet stages.

NOTE

Do not remove the three screws holding the fractionating tube to the top stage.

Technical Information

To reassemble the jet:

- 1 If the center jet rod was removed or loosened during disassembly, thread the rod back into the boilerplate. The top of the rod should be roughly 1/16" to 1/8" below the top surface of the inlet flange (inlet plane of the pump). Once properly located, use the nut near the boilerplate to lock the rod in place.
- 2 Reassemble the lower stages by stacking them (outside the pump body).
- 3 Lower the second stage and fractionating tube into the lower jet assembly, aligning the two slots on the tube with the frame of the jet base. Ensure that the slots are engaged by attempting to rotate it.
- 4 Install the second stage jet shield.
- 5 Install the tie rods through the two holes in the cross member and thread them into the frame on the jet base.
- 6 Thread the two nuts on the tie rods. The height of the tie rods should be adjusted as needed by threading them into the frame of the jet base such that the rods extend above the nuts by roughly 1/8".

CAUTION

Do not over tighten the nuts on the tie rods. Doing so will distort the cross member. The rods are meant to hold the assembly together during installation in the pump.

- 7 Using the cross member and the appropriate lifting equipment, lower the entire jet assembly into the pump body, over the center jet rod.

CAUTION

If the pump has been equipped with a thermowell near the bottom of the pump body, there is a corresponding slot in the jet base for clearance around the thermowell. Ensure that the slot engages the thermowell to avoid damage to the thermowell and jet.

- 8 Reverse steps 1 through 3 above to reassemble the upper jet components.

NOTE

The hex nut is installed such that the small diameter acts to center the cold cap or halo baffle. Ensure that the hex nut is not installed upside down.

NHS-35 Jet Assembly

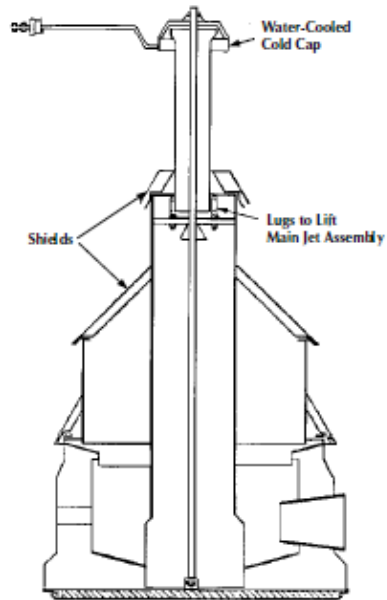


Figure 29 NHS-35 Jet Assembly

To disassemble the jet:

- 1 Unscrew and remove the hex nut holding the cold cap in place. Note its orientation prior to removal
- 2 Remove the cold cap (or halo baffle) as described in "Cold Cap".
- 3 Unscrew the top jet cap and remove.
- 4 Remove the spacer and top jet orifice plug.
- 5 Lift the second stage and jet shield over the center threaded jet rod.
- 6 Using the two eyebolts now accessible and appropriate lifting equipment, lift the entire lower jet assembly out of the pump body, leaving the jet rod in place.
- 7 Remove the third stage jet shield.
- 8 Remove the securing nuts and lift the third stage and fractionating tube off the fourth stage.
- 9 Remove the fourth state jet shield.
- 10 Remove the securing nuts and separate the fourth stage from the jet base.
- 11 Clean and service as needed.

Technical Information

To reassemble the jet:

- 1** If the center jet rod was removed or loosened during disassembly, thread the rod back into the boilerplate. The top of the rod should be roughly 1/16" to 1/8" below the top surface of the inlet flange (inlet plane of the pump). Once properly located, use the nut near the boilerplate to lock the rod in place.
- 2** Reverse steps 7 through 10 above to reassemble the lower jet assembly.
- 3** Using the two eyebolts and the appropriate lifting equipment, lower the lower jet assembly into the pump body over the jet rod. The ejector should be aligned directly across from the foreline. A locating slot on the jet base engages a block in the pump body to ensure the ejector is properly aligned with the foreline.

CAUTION

The jet will not seat properly and the pump will not function unless the slot is engaged on the locator block. Check the engagement by attempting to rotate the jet once in place.

- 4** Reverse steps 1 through 5 above to reassemble the upper jet components.

NOTE

The top jet orifice plug must be seated in the tube with the machined relief down into the tube. Ensure that the plug is not installed upside down.

NOTE

The hex nut is installed such that the small diameter acts to center the cold cap or halo baffle. Ensure that the hex nut is not installed upside down.

Heater Replacement Procedure

The following figure shows the components of the heater element assembly. The heater replacement procedure is the same for all large diffusion pumps*.

WARNING



Use the following precautions when handling the fiberglass insulator and wires as the fiberglass insulator contains RCF, a potentially carcinogenic material.

- Wear long sleeves
- Wear hand gloves
- Wear face mask
- Don't use air pressure to blow on fiberglass

NOTE

During heater replacement, the crush plate* must be replaced if the heaters are removed for inspection or maintenance.

* The NHS-35 does not use a crush plate. Additional studs are used to assure adequate contact between the heater and the boiler plate.

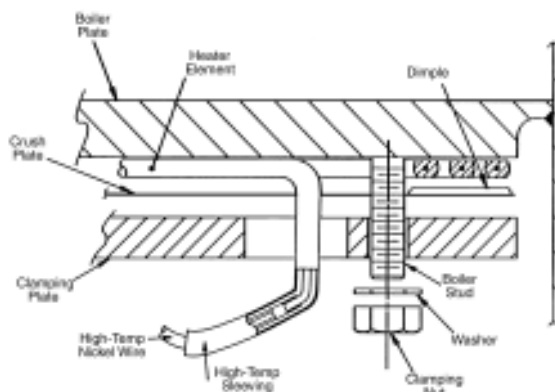


Figure 30 Heater Element Assembly

WARNING



High voltage (up to 480 V) can kill.

Always break the primary circuit to the power supply before starting to work on the heater or its wiring.

CAUTION

Poor clamping resulting in inadequate thermal contact may result in reduced heater life and poor pump performance. Tighten nuts finger-tight on clamping plate, then gradually and evenly tighten them to 250 inches-pounds of torque.

To replace a heater:

- 1 Use an ohmmeter at the electrical box to determine which heater element has failed.
- 2 Disconnect its leads from the terminal strip.
- 3 Pull the leads out of the terminal box and then out of the elbow cover plate.
- 4 Remove the heater cover from the bottom of the diffusion pump. Move the insulation to expose the faulty heaters.
- 5 Spray heater clamp nuts with penetrating oil.
- 6 Remove the nuts holding down the clamping plate.
- 7 Lower the entire heating unit (heater element, clamping plate and crush plate (except for the NHS-35 which does not have a crush plate) until it is off the mounting studs.

Installing the new heater:

- 1 Apply an anti-seize compound such as Loctite C5-A to the top 3/4" of the studs.

CAUTION

You must apply anti-seize compounds to the studs during heater replacement. Failure to do so will cause the nut to seize to the stud and increase the possibility of stud breakage during the next heater replacement.

- 2 Assemble the new unit consisting of the heater element, clamping plate, and crush plate (except for the NHS-35).
- 3 Support the heating unit by the clamping plate, line up the holes with the boiler studs, and push the unit up against the boiler plate. Use two nuts finger-tight to hold it in place.

Technical Information

- 4 Screw on the remaining nut(s) finger-tight, then tighten all nuts evenly to 250 inches-pounds of torque.
- 5 Check the heater alignment with the crush plate. The heater must be located inside the crush plate tabs on all three sides.
- 6 Label the heater leads according to the schematic diagram.
- 7 Run the wires around the periphery of the pump, under the wire retaining clips, into the conduit, and up into the junction box.
- 8 Connect the leads to the terminal strip then replace the elbow cover plate.
- 9 Replace the heater insulation (not shown in Figure 30) between the high temperature nickel wires and the clamping plate.
- 10 Replace the heater cover.

CAUTION

Heater wiring and terminal lugs must not use copper or copper-plated wire which could oxidize rapidly and fail due to the high temperatures near the heaters.

Use #10 strand nickel wire with high temperature insulation.

Troubleshooting

Leakage

If leakage is the suspected cause of poor system performance, first check the following items:

- Inlet and foreline connections
- Drain and fill plugs
- Other compression fittings, such as high-vacuum gauges in the system
- Threaded connections, such as a foreline gauge.

Before proceeding with a program of step-by-step troubleshooting, check the performance and accuracy of the vacuum gauges used on the system.

Outgassing

High-vacuum systems, even without external leakage, can have high gas loads due to outgassing from internal surfaces or processes. The pressure in the system is a result of gas load divided by pumping speed ($p = Q/S$). If the gas load Q exceeds the maximum throughput capability of the diffusion pump, the diffusion pump will not function and the pumping action will essentially be due to the mechanical backing pump.

To estimate the gas load, isolate the system from all pumps after evacuation and measure the rate of pressure increase.

The gas load can be estimated from the following relationship:

$$Q = \frac{V \times \Delta P}{\Delta t}$$

where V is the isolated volume, ΔP is the pressure rise, and Δt is the time period of measurement.

Poor Pump or System Performance

The following table lists the faults, the probable causes and corrective actions to take if you have a problem with a large diffusion pump.

Table 25 Troubleshooting Guide

Fault	Probable Cause	Corrective Action
Poor system pressure	Leaks in system, virtual or real	Locate and repair
	High process gas load	Measure gas load, eliminate cause
	System dirty	Clean system to reduce outgassing
Poor ultimate pressure	Contaminated pump fluid	Examine and clean pump; replace fluid
	Low heat input	Check voltage. Check for continuity, burned-out element, poor thermal contact
	Inadequate cooling water flow	Check water pressure. Check tubing for obstructions and backpressure
	Cooling water is too cold	Check temperature
	Cooling water flow is too high	Adjust water flow
	High forepressure	Check for leak in foreline, poor mechanical pump performance, breakdown of mechanical pump fluid
	Water in Quick Cool coil	Check and remove cause
Slow pumpdown	Low heat input	Check heaters
	Low fluid level	Add fluid
	Malfunctioning pump assembly	Check and repair or replace
	Improperly located jets	
	Damaged jet system	
Inlet pressure surges	Incorrect heater input	Check and correct
	Fluid outgassing	Condition fluid by operating the pump for a few hours
	Leak in system ahead of pump inlet	Check and correct

Table 25 Troubleshooting Guide (Continued)

Fault	Probable Cause	Corrective Action
High chamber contamination of the pump fluid	Forepressure too high	Check for leak in foreline, poor mechanical pump performance, breakdown of pump fluid, and incorrect valve operation
	Prolonged operation in overload range	Adhere to operating procedures
	Cutting over from the backing pump too early in the pump down cycle	Cut over at a lower chamber pressure
	Improper system operation and air release procedures	Adhere to operating procedures
Pump will not start	Safety circuits or protective devices prevent contactor from staying closed	Check utilities, flow devices switches, interlocks. Check thermostat operation

Accessories and Spare Parts

When ordering replacement parts, quote type number and serial number of pump. The following tables show the HS-16, HS-20, HS-32 and NHS-35 accessories and spare parts.

Table 26 HS-16 Accessories and Spare Parts

Part Number	Description
79299301	Cold cap assembly, includes No.10-32 SST Rd Hd screw and No. 10-32 SST hex nut)
L8839301	Cold cap gasket set
L8840301	Cold cap nut and follower set
83612401	Jet assembly
80798301	Foreline baffle assembly
77261001	Fill and drain plug
L8841301	Thermoswitch kit (upper and lower switch, 4' Ni wire 14 AWG, 6 Ni Lugs)
647316027	Heater element with leads (3200 W, 200 V)
647316037	Heater element with leads (2700 W, 400 V)
647316038	Heater element with leads (3200 W, 400 V)
647316039	Heater element with leads (2700 W, 430 V)
647316041	Heater element with leads (2700 W, 440 V)
647316042	Heater element with leads (3200 W, 440 V)
647316020	Heater element with leads (2700 W, 240 V Delta, 415 V WYE)
647316030	Heater element with leads (2700 W, 480 V)
647316023	Heater element with leads (3200 W, 240 V Delta, 415 V WYE)
647316033	Heater element with leads (3200 W, 480 V)
647316051	Heater element with leads (3200 W, 380 V)
647316380	Heater element with leads (2700 W, 380 V)
647316460	Heater element with leads (2700 W, 460 V)
647316021	Heater element with leads (2700 W, 575 V)
K4919001	Heater crush plate, required with heater replacement
K4917001	Heater clamping plate
79309001	Heater insulating blanket

Technical Information

Table 26 HS-16 Accessories and Spare Parts (Continued)

Part Number	Description
79308001	Heater cover plate
K0377164	O-ring kit; includes: <ul style="list-style-type: none">❑ 1 Butyl ASA inlet O-ring (48214001)❑ 1 Buna-N ASA foreline O-ring (660890348)❑ 8 Viton fill and drain O-rings (660892213)❑ 1 Sight glass O-ring (660892232)❑ 1 Graphite sight glass gasket (K8478001)
Commercial Item	Cold cap fitting, Imperial flex fitting #66-FL, 1/2" OD tube x 3/8" FPT
K8475001	Sight glass
L6367301	Jet coupling assembly
X3900-68000	HS-16/20 heater wire, 120" 10 AWG
X3900-68006	HS-16/20 thermo switch wire, 14 AWG, 80" length
648056329	Ni lug, 14 AWG

Technical Information

Table 27 HS-20 Accessories and Spare Parts

Part Number	Description
84358301	Cold cap assembly, includes No.10-32 SST Rd Hd screw and No. 10-32 hex nut SST
L8839301	Cold cap gasket kit
F2622001	Cold cap follower, brass
75786001	Cold cap nut
622445026	Cold cap female coupling, 1/2" OD tube x 3/8" FPT, Imperial Flexfitting No. 66-FL
L6367301	Jet coupling assembly
84350301	Jet assembly
84889301	Foreline baffle assembly
F6097301	Sight glass service kit, includes glass tube, O-rings, and fittings Valves not included for pumps built prior to October 1994
77261001	Threaded plug, fill and drain
K9050001	Upper thermal switch, Temperature setting: 185 °F
K9050002	Lower thermal switch, Temperature setting: 390 °F
X3900-68006	HS-16/20 thermo switch wire, 14 AWG, 80" length
648056329	Ni lug, 14 AWG
X3900-68000	HS-16/20 heater wire, 120" 10 AWG
647320025	Heater element with leads (2,000 W, 200 V)
647320020	Heater element with leads (2,000 W, 240 V Delta, 415 V WYE)
647320035	Heater element with leads (2,000 W, 400 V)
647320040	Heater element with leads (2,000 W, 430 V)
647320045	Heater element with leads (2,000 W, 440 V)
647320030	Heater element with leads (2,000 W, 480 V)
647320208	Heater element with leads (2,000 W, 208 V)
647320022	Heater element with leads (2,000 W, 220 V)
647320050	Heater element with leads (2,000 W, 265 V)
647320380	Heater element with leads (2,000 W, 380 V)
647320044	Heater element with leads (2,000 W, 420 V)
647320046	Heater element with leads (2,000 W, 460 V)
647320075	Heater element with leads (2,000 W, 575 V)
K7108001	Crush plate, replace with each heater

Table 27 HS-20 Accessories and Spare Parts (Continued)

Part Number	Description
K7107001	Clamping plate
L6514001	Insulation for heaters, Cerablanket 0.50" thick
84497001	Heater cover plate
L9223001	Sight glass (for pumps built after October 1994)
K0377165	O-ring kit; includes: <ul style="list-style-type: none">❑ 1 butyl O-ring for ASA inlet flange (84349002)❑ 1 butyl foreline flange O-ring (660893432)❑ 8 Viton fill and drain O-rings (660892213)❑ 1 Sight glass O-ring (660892240)❑ 1 Graphite sight glass gasket (L9228001)

Technical Information

Table 28 HS-32 Accessories and Spare Parts

Part Number	Description
77252801	Cold cap assembly, includes No.10-32 SST Rd Hd screw and No. 10-32 hex nut SST
L8839301	Cold cap gasket kit
F2622001	Cold cap follower (brass)
75786001	Cold cap nut
622445026	Cold cap female coupling, 1/2" OD tube x 3/8" FPT, Imperial Flexfitting No. 66-FL
76511301	Jet assembly
F6097301	Sight glass service kit (includes glass tube, O-rings, and fittings; valves not included)
77261001	Threaded plug, fill and drain
K9050003	Upper thermal switch, Temperature setting: 220 °F
K9050004	Lower thermal switch, Temperature setting: 550 °F
X3900-68007	HS-32/35 thermo switch wire, 14 AWG, 92" length
648056329	Ni lug, 14 AWG
X3900-68003	HS-32/35 heater wire, 196" 10 AWG
F6253001	Thermal switch block, brass
647332010	Heater element with leads, No. 10 AWG (4000 W, 240 V Delta, 415 V Wye, 480 V Delta)
647332015	Heater element with leads (4000 W, 220 V)
647332040	Heater element with leads (4000 W, 400 V)
647332044	Heater element with leads (4000 W, 440 V)
K7246001	Heater crush plate, replace with each new heater
K7247001	Clamping plate
75792001	Insulation for heaters – Cerablanket 0.50" thick
75791001	Heater cover
670099910	Insulation for conduit
L9223001	Sight glass (for pumps built after October 1995)
K0377167	O-ring kit; includes: <ul style="list-style-type: none"> ❑ 1 butyl O-ring for ASA inlet flange (45390001) ❑ 1 butyl O-ring foreline flange (2-443) ❑ 8 Viton fill and drain O-rings (2-213) ❑ 1 Sight glass O-ring (2-240) ❑ 1 Graphite sight glass O-ring (L9228001) ❑ 4 Viton O-rings (2-221)

Technical Information

Table 29 NHS-35 Accessories and Spare Parts

Part Number	Description
F1971302	Jet Assembly
81437301	Cold cap assembly (includes No.10-32 SST Rd Hd screw and No. 10-32 hex nut) SST
L8839301	Cold cap gasket kit
F2622001	Cold cap follower (brass)
75786001	Cold cap nut
622445026	Cold cap female coupling, 1/2" OD tube x 3/8" FPT, Imperial Flexfitting No. 66-FL
F1744301	Foreline baffle assembly
77261001	Threaded plug, fill and drain
K9050005	Upper thermal switch, Temperature setting: 200 °F
K9050006	Lower thermal switch, Temperature setting: 600 °F
647335010	Heater element with leads (4000 W, 240 V Delta, 415 V WYE, 480 V Delta)
647335012	Heater element with leads (4000 W, 220 V)
647335380	Heater element with leads (4000 W, 380 V)
647335014	Heater element with leads (4000 W, 460 V)
L6383010	Heater element with leads (4000 W, 400 V)
L6383011	Heater element with leads (4000 W, 440 V)
F1749001	Clamping plate (no crushplate in NHS-35)
L9699001	Insulation for heaters – Cerablanket 0.50" thick
L9223001	Sight glass (for pumps built after October 1995)
K0377169	O-ring kit; includes: 1 Butyl O-ring for ASA inlet flange (78536001) <input type="checkbox"/> 1 Butyl O-ring foreline flange (2-267) <input type="checkbox"/> 8 Viton O-rings fill and drain (2-213) <input type="checkbox"/> 1 Sight glass O-ring (2-240) <input type="checkbox"/> 1 Graphite sight glass gasket (L9228001) <input type="checkbox"/> 4 Viton O-rings (2-221)
78536002	O-ring for ISO inlet flange
X3900-68007	HS-32/35 thermo switch wire, 14 AWG, 92" length
648056329	Ni lug, 14 AWG
X3900-68003	HS-32/35 heater wire, 196" 10 AWG



Vacuum Products Division

Dear Customer,

Thank you for purchasing an Agilent vacuum product. At Agilent Vacuum Products Division we make every effort to ensure that you will be satisfied with the product and/or service you have purchased.

As part of our Continuous Improvement effort, we ask that you report to us any problem you may have had with the purchase or operation of our products. On the back side you find a Corrective Action request form that you may fill out in the first part and return to us.

This form is intended to supplement normal lines of communications and to resolve problems that existing systems are not addressing in an adequate or timely manner.

Upon receipt of your Corrective Action Request we will determine the Root Cause of the problem and take the necessary actions to eliminate it. You will be contacted by one of our employees who will review the problem with you and update you, with the second part of the same form, on our actions.

Your business is very important to us. Please, take the time and let us know how we can improve.

Sincerely,

Giampaolo LEVI

*Vice President and General Manager
Agilent Vacuum Products Division*

Note: Fax or mail the Customer Request for Action (see backside page) to Agilent Vacuum Products Division (Torino) – Quality Assurance or to your nearest Agilent representative for onward transmission to the same address.

CUSTOMER REQUEST FOR CORRECTIVE / PREVENTIVE / IMPROVEMENT ACTION

TO: AGILENT VACUUM PRODUCTS DIVISION TORINO – QUALITY ASSURANCE FAX

N°: XXXX-011-9979350

ADDRESS: AGILENT TECHNOLOGIES ITALIA S.p.A. – Vacuum Products Division –

Via F.Ili Varian, 54 – 10040 Leini (TO) – Italy

E-MAIL: vpd-qualityassurance_pdl-ext@agilent.com

NAME	COMPANY	FUNCTION
ADDRESS:		
TEL. N° : FAX N° :		
E-MAIL:		
PROBLEM / SUGGESTION :		
REFERENCE INFORMATION (model n°, serial n°, ordering information, time to failure after installation, etc.):		
DATE		
CORRECTIVE ACTION PLAN / ACTUATION (by AGILENT VPD)		LOG N°

XXX = Code for dialing Italy from your country (es. 01139 from USA; 00139 from Japan, etc.)



Agilent Technologies



Vacuum Products Division Instructions for returning products

Dear Customer,

Please follow these instructions whenever one of our products needs to be returned.

Complete the attached **Request for Return** form and send it to Agilent Technologies (see below), taking particular care to include the completed **Health and Safety** declaration Section. No work can be started on your unit until we receive a completed copy of this form.

After evaluating the information, Agilent Technologies will provide you with a **Return Authorization (RA)** number via email or fax, as requested. Note: Depending on the type of return, a Purchase Order may be required at the time the **Request for Return** is submitted. We will quote any necessary services (evaluation, repair, special cleaning, eg).

Product preparation

- Remove all accessories from the core product (e.g. inlet screens, vent valves).
- Prior to shipment and if applicable for your product, drain any oils or other liquids, purge or flush all gasses, and wipe off any excess residue.
- If ordering an Advance Exchange product, please use the packaging from the Advance Exchange to return the defective product.
- Seal the product in a plastic bag, and package product carefully to avoid damage in transit. You are responsible for loss or damage in transit.
- Include a copy of the Health and Safety Declaration in the shipping documentation on the outside of the shipping box of your returning product.
- Clearly label package with RA number. Using the shipping label provided will ensure the proper address and RA number are on the package. Packages shipped to Agilent without a RA clearly written on the outside cannot be accepted and will be returned.
- Return only products for which the RA was issued.

Shipping

- Ship to the location specified on the printable label, which will be sent, along with the RA number, as soon as we have received all of the required information. Customer is responsible for freight charges on returning product.
- Return shipments must comply with all applicable Shipping Regulations (IATA, DOT, ADR, etc.) and carrier requirements.

RETURN THE COMPLETED REQUEST FOR RETURN FORM TO YOUR NEAREST LOCATION:

EUROPE:

Fax: 00 39 011 9979 330

Fax Free: 00 800 345 345 00

Toll Free: 00 800 234 234 00

vpt-customer care@agilent.com

NORTH AMERICA:

Fax: 1 781 860 9252

Toll Free: 800 882 7426

vpl-ra@agilent.com

PACIFIC RIM:

please visit our website for individual
office information

<http://www.agilent.com>



TERMS AND CONDITIONS

Please read the terms and conditions below as they apply to all returns and are in addition to the Agilent Technologies Vacuum Product Division – Products and Services Terms of Sale.

- Unless otherwise pre-negotiated, customer is responsible for the freight charges for the returning product. Return shipments must comply with all applicable **Shipping Regulations** (IATA, DOT, etc.) and carrier requirements.
- Agilent Technologies is not responsible for returning customer provided packaging or containers.
- Customers receiving an Advance Exchange product agree to return the defective, rebuildable part to Agilent Technologies **within 15 business days**. Failure to do so, or returning a non-rebuildable part (crashed), will result in an invoice for the non-returned/non-rebuildable part.
- Returns for credit toward the purchase of new or refurbished Products are subject to prior Agilent approval and may incur a restocking fee. Please reference the original purchase order number.
- Units returned for evaluation will be evaluated, and a quote for repair will be issued. If you choose to have the unit repaired, the cost of the evaluation will be deducted from the final repair pricing. A Purchase Order for the final repair price should be issued within 3 weeks of quotation date. Units without a Purchase Order for repair will be returned to the customer, and the evaluation fee will be invoiced.
- Products returned that have not been drained from oil will be disposed.
- A Special Cleaning fee will apply to all exposed products
- If requesting a calibration service, units must be functionally capable of being calibrated.

**Vacuum Products Division
Request for Return Form**

Customer information		
Company :		Contact Name:
Address:		Tel: Fax:
		Email:

Equipment			
Product description	Agilent PartNo	Agilent Serial No	Original Purchasing Reference
Failure description		Type of process (for which the equipment was used)	

Type of return
<input type="checkbox"/> Non Billable <input type="checkbox"/> Billable ➡ New PO # (hard copy must be submitted with this form): _____
<input type="checkbox"/> Exchange <input type="checkbox"/> Repair <input type="checkbox"/> Upgrade <input type="checkbox"/> Consignment/Demo <input type="checkbox"/> Calibration <input type="checkbox"/> Evaluation <input type="checkbox"/> Return for Credit

Health and safety		Substances (please refer to MSDS forms)			
The product has been exposed to the following substances: (by selecting 'YES' you MUST complete the table to the right)		* Agilent will not accept delivery of any product that is exposed to radioactive, biological, explosive substances or dioxins, PCB's without written evidence of decontamination.			
		Trade name	Chemical name	Chemical Symbol	CAS Number
Toxic	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Harmful	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Corrosive	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Reactive	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Flammable	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Explosive (*)	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Radioactive (*)	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Biological (*)	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Oxidizing	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Sensitizer	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Other dangerous substances	<input type="checkbox"/> YES <input type="checkbox"/> NO				

Goods preparation	
If you have replied YES to one of the above questions. Has the product been purged?	<input type="checkbox"/> YES <input type="checkbox"/> NO
If yes, which cleaning agent/method:	
Has the product been drained from oil?	<input type="checkbox"/> YES <input type="checkbox"/> NOT APPLICABLE
I confirm to place this declaration on the outside of the shipping box. <input type="checkbox"/>	

I declare that the above information is true and complete to the best of my knowledge and belief. I understand and agree to the terms and conditions on page 2 of this document.	
Name:	Authorized Signature:
Position:	
Date:	
NOTE: If a product is received at Agilent which is contaminated with a toxic or hazardous material that was not disclosed, the customer will be held responsible for all costs incurred to ensure the safe handling of the product, and is liable for any harm or injury to Agilent employees as well as to any third party occurring as a result of exposure to toxic or hazardous materials present in the product.	

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