Instruction Manual

HT16B and HT20B High Throughput Diffusion Pumps

Description	Voltage	Item Numbers		
		ANSI16/ANSI3 Inlet/Outlet (Basic)	ANSI16/ANSI3 Inlet/Outlet (Harting)	ISO500/ISO100 Inlet/Outlet
HT16B High Throughput Diffusion Pumps	200 V	B312-20-200	B312-21-200	B312-22-200
	220 V	B312-20-220	B312-21-220	B312-22-220
	380 V	B312-20-380	B312-21-380	B312-22-380
	400 V	B312-20-400	B312-21-400	B312-22-400
	415 V	B312-20-415	B312-21-415	B312-22-415
	440 V	B312-20-440	B312-21-440	B312-22-440
	460 V	B312-20-460	B312-21-460	B312-22-460
	480 V	B312-20-480	B312-21-480	B312-22-480

Description	Voltage	Item Numbers	
		ANSI20/ANSI4 Inlet/Outlet	ISO630/ISO160 inlet/outlet
HT20B High Throughput Diffusion Pumps	200 V	B314-20-200	B314-22-200
	220 V	B314-20-220	B314-22-220
	380 V	B314-20-380	B314-22-380
	400 V	B314-20-400	B314-22-400
	415 V	B314-20-415	B314-22-415
	440 V	B314-20-440	B314-22-440
	460 V	B314-20-460	B314-22-460
	480 V	B314-20-480	B314-22-480

Description	Voltage	Item Number
		ANSI20/ANSI4 Inlet/Outlet
HT20B High Throughput Diffusion Pump Fitted with Thermal Probe Accessory B61421000	380 V	B314-28-380

Declaration of Conformity

We, Edwards,
Innovation Drive,
Burgess Hill,
West Sussex,
RH15 9TW, UK

declare under our sole responsibility, as manufacturer and person within the EU authorised to assemble the technical file, that the product(s)

HT16B and HT20B Vapour Diffusion Pumps

B312-20-xxx	B314-20-xxx
B312-21-xxx	B314-22-xxx
B312-22-xxx	

Where xxx is the supply voltage (200, 220, 380, 400, 415, 440, 460, 480)

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN1012-2:1996+A1:2009	Compressors and Vacuum Pumps. Safety Requirements. Vacuum Pumps
EN60204-1:2006+A1:2009	Safety of machinery. Electrical equipment of machines. General Requirements

and fulfils all the relevant provisions of

2014/35/EU	Low Voltage Directive

Note: This declaration covers all product serial numbers from the date this Declaration was signed onwards.

Mr Peter Meares
Senior Technical Support Manager, General Vacuum

10.05.2016, Burgess Hill

Date and Place

This product has been manufactured under a quality management system certified to ISO 9001:2008

P200-10-036
Issue A

Materials Declaration

In accordance with the requirements of the Chinese regulatory requirement on the Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products Order No. 32 (also known as 'China RoHS2') and SJ/T 11364 Marking for the Restricted Use of Hazardous Substances in Electronic and Electrical Products:

Product Labels

Product	Product Label	Meaning
All pumps in the list below		This product contains hazardous substances in at least one of the homogeneous materials used which are above the limit requirement in GB/T 26572 as detailed in the declaration table below. These parts can safely be used for the environmental protection use period as indicated.

Pump Type	Pump Size
Diffusion Pumps	Diffstak 63, 100, 160, 250
Vapour Boosters	30B5, 18B4
High Throughput Pumps	HT10, 16, 20

材料成分声明
Materials Content Declaration

部件名称 Part name	危险物质 Hazardous Substances					
	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr VI)	多溴联苯 Polybrominated biphenyls (PBB)	多溴二苯醚 Polybrominated diphenyl ethers (PBDE)
铸铝 Cast Aluminium	X	O	O	O	O	O
铜管管件 Brass pipe Fittings	X	O	O	O	O	O
铜接头 Brass Connectors	X	O	O	O	O	O

O： 表示该有害物质在该部件的所有均质材料中的含量低于 GB/T 26572 标准规定的限量要求。
O: Indicates that the hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in GB/T 26572.
X： 表示该有害物质在该部件的至少一种均质材料中的含量超出 GB/T26572 标准规定的限量要求。
X: Indicates that the hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement of GB/T26572.

NOTES: These products are EU RoHS compliant, the following Exemptions apply:
6(b) **Lead** as an alloying element in aluminium containing up to 0.4% by weight.
6(c) Copper alloy containing up to 4% **lead** by weight

Packaging Information

Pallet	Over-shipper	Protection Pieces	Support Braces
			
Recyclable Natural Wood	Recyclable Cardboard	Recyclable Polypropylene	Recyclable Mild Steel

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Contents

Associated publications

Publication title	Publication number
HT Pump Accessories	B611-01-880

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1 Introduction

1.1 Scope and definitions

This manual provides installation, operation and maintenance instructions for the Edwards HT16B and HT20B High Throughput Diffusion Pumps, abbreviated to "HT pump" or "pump" in the remainder of this manual. You must use the HT16B and HT20B pumps as specified in this manual.

Read this manual before you install and operate the pump. Important safety information is highlighted as WARNING and CAUTION instructions; you must obey these instructions. The use of WARNINGS and CAUTIONS is defined below.

WARNING

Warnings are given where failure to observe the instruction could result in injury or death to people.

CAUTION

Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment and process.

The following IEC warning labels appear on the pump:

Warning - refer to accompanying documentation.

Warning - risk of electric shock.

Warning - hot surface.

The units used throughout this manual conform to the SI international system of units of measurement.

The pump identification and rating plate (Figure 2, item 3) provides specific details about the pump, including: pump type; part number and serial number; mass; name and address of manufacturer; and so on.

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1.2 Description

1.2.1 The HT pump

The HT pumps are water-cooled, high throughput diffusion pumps. An over-temperature protection facility is provided and this must be connected into your pump control circuit.

Refer to Figure 1 which shows the component parts of the pump.

The pump has a welded tubular body assembly and a precision machined interior with accurate vapour jet gaps. The body assembly has an inlet-flange (2), a main body tube (37), a base (40) and an outlet-condenser assembly (9). The pump is cooled by water which passes through a tubular copper cooling coil (5) attached to the body and configured to provide optimum cooling. There are four annular jet stages (17, 18, 20, 22) and a conical ejector jet stage (16).

The top-jet has a cool-cap (24) which reduces backstreaming without loss of pumping speed. The cool-cap is water-cooled to accommodate the high operational temperature of the pump.

The pumps are fractionating. This means that the higher vapour pressure fractions of the pump fluid are fed to the lower jets. The top-jet receives the lower vapour pressure fractions. This improves the ultimate vacuum of the pump.

1.2.2 Drain/fill assembly

Refer to Figure 1, detail D. The boiler drain-plug (44) and the fluid-level sight-glass (46) are located on the base of the pump, virtually opposite the backing/ outlet assembly.

You can use the sight-glass to check the pump fluid-level. Removal of the filler plug (43) enables the pump to be filled with pump fluid.

When necessary, the fluid drain plug (44) can be removed to drain the fluid from the pump.

1.2.3 Over-temperature protection

Refer to Figure 1. The HT pump has two thermal snap-switches (10, 11) which are wired in series. The cooling-fail thermal snap-switch (10) monitors the temperature of the cooling-coils (5) and the boiler protection thermal snap-switch (11) monitors the temperature of the base of the pump.

You must connect the snap-switches to your control equipment so that the electrical supply to the pump is switched off if either of the snap-switches open. If you do not use the thermal snap-switches in this manner, the pump may overheat and be seriously damaged. In addition, if the pump overheats, the pump fluid may undergo thermal breakdown (see Section 3.8.2).

The contacts of the thermal snap-switches open at a preset threshold temperature. Once opened, the snap-switches will automatically reset if the temperature of the pump drops below the threshold temperature.

If the electrical supply fails during operation, the snap-switch contacts will not open and the pump will restart after the restoration of the electrical supply unless additional protection measures are used. We therefore recommend that you connect the thermal snap-switches through an interlock circuit (see Section 3.5).

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1.2.4 Pump versions

Note: *The Harting version HT16B pumps are supplied with an Inlet Baffle fitted, however the remainder of this manual describes HT pumps without an Inlet Baffle. Refer to the instruction manual supplied as a Supplementary Publication for information on the effect of the Inlet Baffle.*

Two versions of pump are available, a basic HT (with ANSI or ISO flanges) and a Harting HT16B (with ANSI flanges).

The two versions have different electrical connection configurations:

- On the basic HT, you must connect the electrical supply to the electrical terminals on the pump.
- On the Harting HT16B, you must connect the electrical supply to the pump through an electrical socket.

In addition, the Harting HT16B is supplied with an Inlet Baffle fitted.

1.3 Performance

The pumping speeds and throughputs given in Section 2.2 were calculated from measurements made with total pressure gauges. If partial-pressure gauges are used, the calculated values for pumping speeds are approximately 30% larger. This is because partial-pressure gauges do not measure the pressure added to the system by condensable gases.

The pumping speeds were calculated with reference to international standards. If American Vacuum Society standards are used, the pumping speeds are approximately 10% larger.

We do not give values for the ultimate vacuum of the HT pumps. The ultimate vacuum depends on the fluid used in the pump, the leak tightness of the system, outgassing from surfaces and the use of cold traps.

1.4 Operation with high ambient humidity

When the HT pump is switched off, the heaters in the pump will absorb moisture: this will cause a decrease in the insulation resistance of the heaters. If you operate the pump in an environment with high ambient humidity, this may cause the heaters to fail. The rate of moisture absorption (and therefore the time taken for the insulation resistance of the heaters to fall below the recommended value) depends on the ambient humidity and temperature and the length of time that the pump is switched off.

In addition to the recommendations made in later sections of this manual, you can overcome the effect of high ambient humidity if you:

- Configure the electrical installation of the pump for ‘soft-start’ operation, when the pump is operated with typically 20 to 25% of the nominal supply voltage.
- Install an anti-moisture heater under the base of the pump. Switch on this heater when you switch off the pump.

Detailed information about these recommendations is outside the scope of this manual. If you need more information about the operation of the pump with high ambient humidity, request a copy of our Application Note P400-50-000 from your supplier or Edwards.

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Figure 1 - Pump sectional view

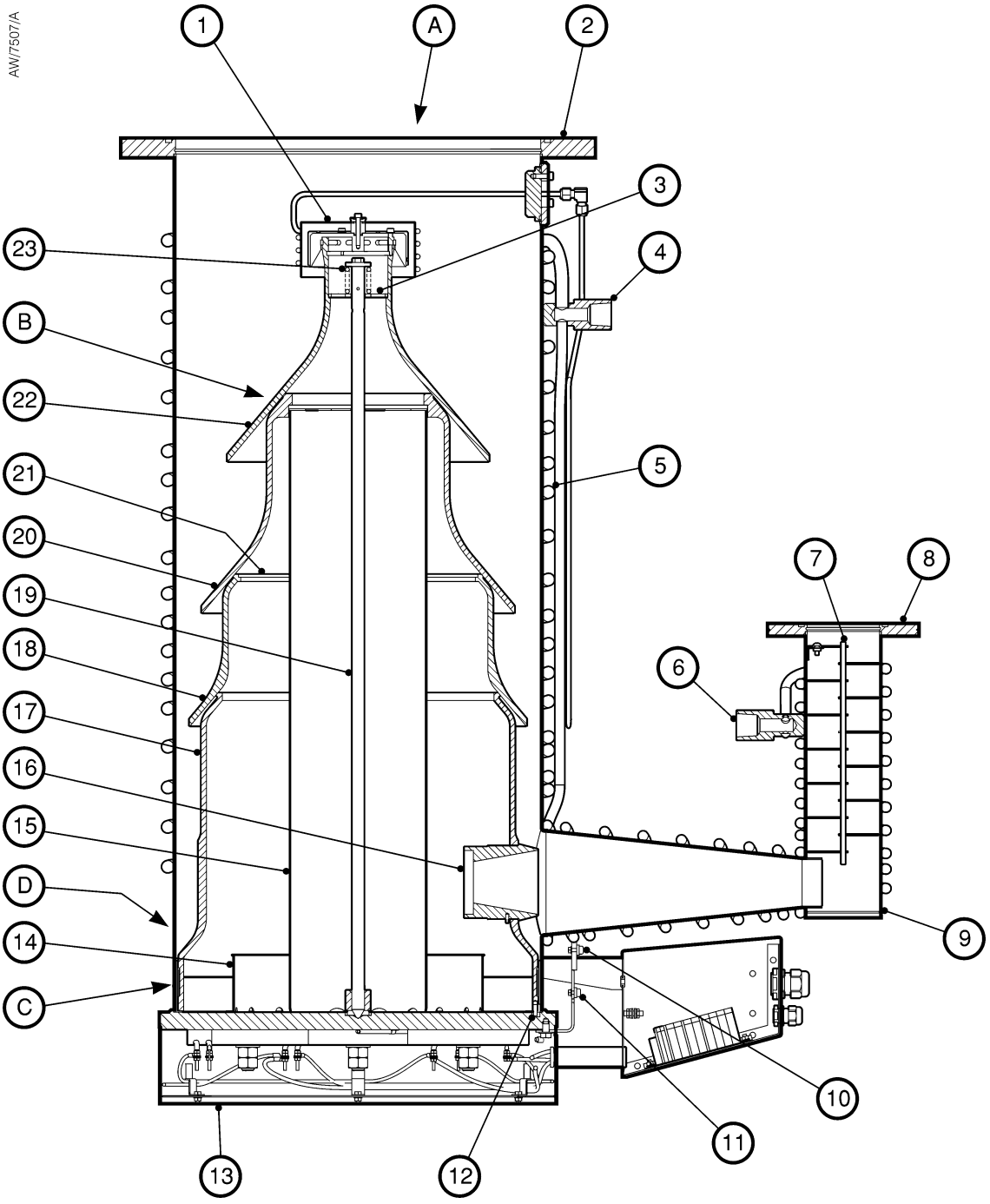

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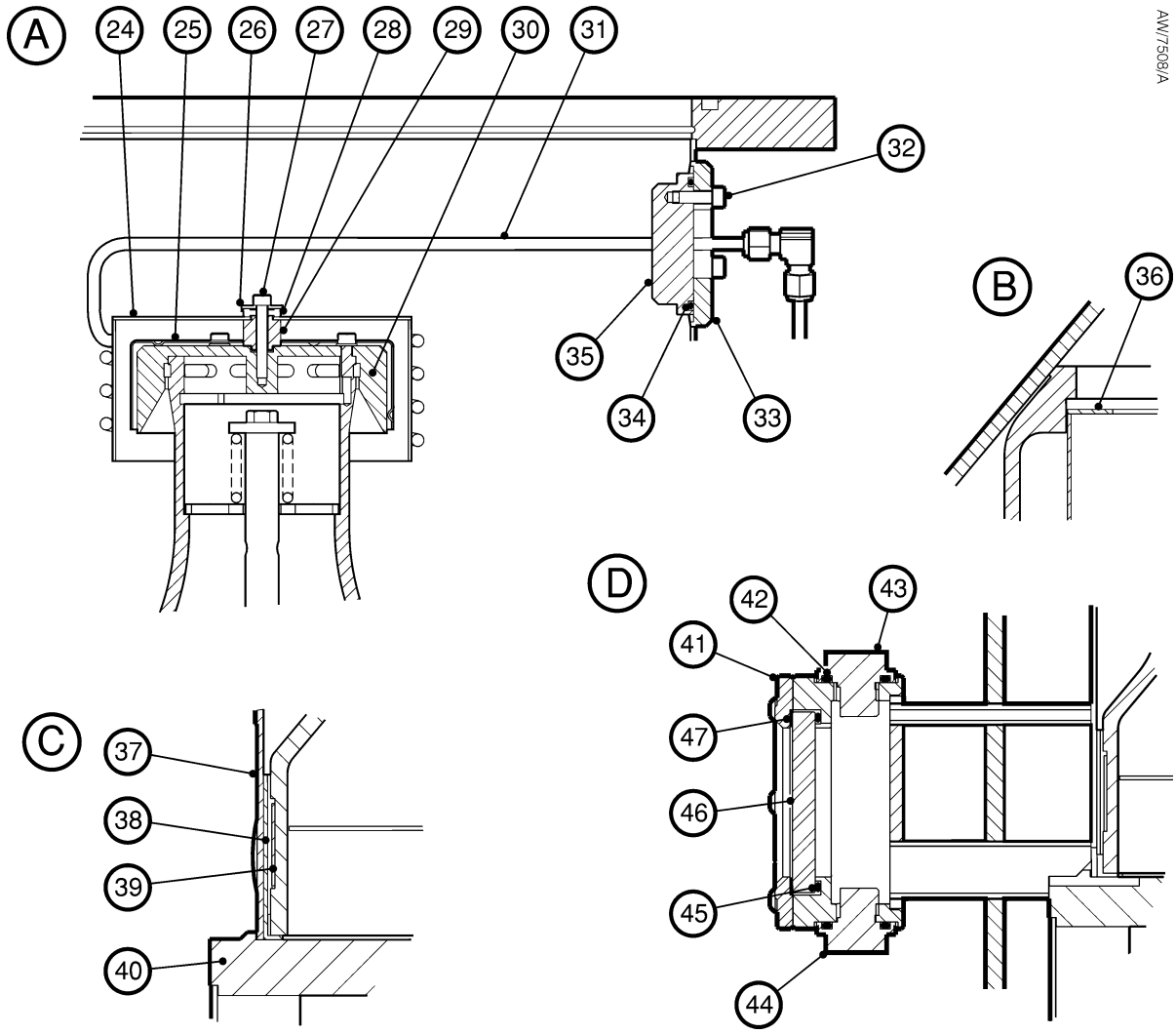
Figure 1 - Pump sectional view (continued)



1. Cool-cap assembly
2. Inlet-flange
3. Top-stage disk
4. Cooling-water inlet
5. Cooling coils
6. Cooling-water outlet
7. Baffle assembly
8. Outlet flange
9. Outlet condenser
10. Cooling-fail thermal snap-switch
11. Boiler protection thermal snap-switch
12. Interior locating pin
13. Base shield
14. Fluid drier
15. Centre tube
16. Ejector nozzle
17. Lower stage
18. Third stage
19. Interior tie-rod
20. Second stage
21. Third stage disk
22. Top stage
23. Spring, disk and fixing bolt
24. Cool-cap
25. Secondary-cap
26. Special washer
27. Fixing screw
28. Ceramic washer
29. Ceramic spacer
30. Top-jet cap
31. Cooling-water tubes
32. Mounting screws
33. Body boss
34. O-ring
35. Connection flange
36. Second stage disc
37. Body tube
38. Outer thermal shield
39. Inner thermal shield
40. Base flange
41. Bezel
42. O-ring
43. Fluid filler plug
44. Fluid drain plug
45. O-ring
46. Fluid-level sight-glass
47. Sight-glass gasket

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1.5 Cooling-water supplies

All of the information given in this manual (technical data, warm-up and cool-down times, and so on) is based on the use of a typical domestic drinking water supply to provide the cooling-water for the HT pump.

If there are additives in the cooling-water, this will affect the heat removal properties of the water, and cooling-water flow rates, temperatures and/or pump warm-up/cool-down times may need to be adjusted.

Therefore, if you want to connect a cooling-water supply which contains additives to the pump (for example, if you want to use a closed-circuit cooling system with external cooling towers, and add an anti-freeze to the cooling-water), you **must** contact Edwards or your supplier for advice.

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2 Technical data

Note: *All of the technical data in this section is based on the use of a typical domestic drinking water supply for the HT pump cooling-water supply: see Section 1.5.*

2.1 Operating and storage conditions

Table 1 - Operating and storage conditions data

	HT16B	**HT20B**
Maximum ambient operating temperature	40 °C	40 °C
Typical surface temperature during operation	150 °C	150 °C
Maximum surface temperature during operation	250 °C	250 °C
Minimum backing pump displacement *	94 $m^3 h^{-1}$	135 $m^3 h^{-1}$
Recommended Edwards backing pump	E2M175, GV80 or GV160M	E2M175 and GV260M

* *For maximum throughput.*

2.2 Performance

Notes: 1. *The temperatures specified below were measured at the edge of the base flange of the HT pump (Figure 1, item 13). The temperatures are therefore different from those specified for the Thermal Probe accessory in the HT Diffusion Pump Accessories instruction manual.*

2. *The performance data specified in this section applies to operation of the pump with DC704EU fluid.*

Table 2 - Performance data

	HT16B	**HT20B**
Performance curves	See Figure 3	See Figure 4
Maximum system pressure (absolute)	300 mbar gauge, 1.3 bar absolute, 1.3 x 10^5 Pa	300 mbar gauge, 1.3 bar absolute, 1.3 x 10^5 Pa
Critical backing pressure	1.4 mbar, 1.4 x 10^2 Pa	1.3 mbar, 1.3 x 10^2 Pa
Pumping speed (ISO) without Inlet Baffle		
Nitrogen	6500 l s^{-1}	10500 l s^{-1}
Helium	8500 l s^{-1}	16000 l s^{-1}
Throughput at 4 x 10^{-3} mbar, 4 x 10^{-1} Pa		
Nitrogen	17.5 mbar l s^{-1}, 1.75 x 10^3 Pa l s^{-1}	24 mbar l s^{-1}, 2.4 x 10^3 Pa l s^{-1}
Helium	29 mbar l s^{-1}, 2.9 x 10^3 Pa l s^{-1}	55 mbar l s^{-1}, 5.5 x 10^3 Pa l s^{-1}
Backstreaming rate at ultimate vacuum	1 x 10^{-3} mg cm^{-2} min^{-1}	1.4 x 10^{-3} mg cm^{-2} min^{-1}
Fluid loss at 4 x 10^{-3} mbar, 4 x 10^{-1} Pa	0.7 g h^{-1}	0.9 g h^{-1}
Warm-up time to operating temperature	60 min	60 min
Warm-up time to maximum throughput	75 min	75 min
Cool-down time (to approximately 100 °C) *	180 min	300 min

* *Allow sufficient time for your pump to cool down before handling.*

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2.3 Mechanical data

Table 3 - Mechanical data

	HT16B	HT20B
Dimensions	See Figure 2	See Figure 2
Maximum stability angle	25°	30°
Mass		
Without fluid	180 kg	270 kg
With full fluid charge	185 kg	275 kg
Inlet flange	ANSI16 or ISO500	ANSI20 or ISO630
Outlet flange	ANSI3 or ISO100	ANSI4 or ISO160
Cooling-water inlet/outlet	$^3/_4$ NPT female	$^3/_4$ NPT female
Cable-glands		
Electrical supply leadthrough *	PG21	PG21
Control cable leadthrough *	PG11	PG11
Cable restraint †	PG29	-

* *Basic HT pump only (see Section 3.5.3).*
† *Harting HT16B pump only. (Only required if conduit is not used: see Section 3.5.2.)*

2.4 Pump fluid data

Note: *An Edwards Material Safety Data Sheet for DC704EU fluid is available on request.*

Table 4 - Pump fluid data

		HT16B	HT20B
Pump fluid charge (dry)		3000 ml	5000 ml
Pump fluid charge (wet)		2600 ml	4400 ml
Pump fluid charge (minimum)		1000 ml	2500 ml
Pump fluid type	**Flash point**	**Auto-ignition point**	**Molecular weight**
DC704EU	221 °C	500 °C	484

2.5 Cooling-water data

Table 5 - Cooling-water data

	HT16B	HT20B
Minimum allowed water inlet temperature	10 °C	10 °C
Maximum allowed water outlet temperature	35 °C	35 °C
Minimum cooling-water flow rate (at 25 °C)	700 l h^{-1}	960 l h^{-1}
Maximum cooling-water supply pressure	5 bar gauge, 72.5 psig	5 bar gauge, 72.5 psig
Pressure differential across supply and return *	1 bar absolute, 14.5 psi absolute	1 bar absolute, 14.5 psi absolute

* *At minimum cooling-water flow.*

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2.6 Electrical data

Table 6 - Electrical data

	HT16B	HT20B
Heaters		
Voltage	200, 220, 380, 400, 415, 440, 460 or 480 V	200, 220, 380, 400, 415, 440, 460 or 480 V
Power	1.5 kW x 6 (9 kW)	1.4 kW x 9 (12.6 kW)
Over-current protection setting		
200 V, 50/60 Hz	29 A	40.0 A
220 V, 50/60 Hz	26.3 A	37.0 A
380 V, 50/60 Hz	15.2 A	21.5 A
400 V, 50/60 Hz	14.5 A	20.5 A
415 V, 50/60 Hz	14.0 A	19.5 A
440 V, 50/60 Hz	13.2 A	18.5 A
460 V, 50/60 Hz	12.6 A	18.0 A
480 V, 50/60 Hz	12.1 A	17.0 A
Maximum control voltage	277 V a.c.	277 V a.c.
Recommended control voltage	24 V a.c.	24 V a.c.
Maximum control current	6.3 A at 250 V a.c.	6.3 A at 250 V a.c.
Minimum voltage ratings for supply and control cables		
Between conductors and earth (ground)	600 V	600 V
Between conductors	1000 V	1000 V
Recommended cable sizes		
Electrical supply cable(s) *	13 to 18 mm outside diameter	13 to 18 mm outside diameter
Control cable *	5 to 10 mm outside diameter	5 to 10 mm outside diameter
Electrical supply and control cable †	19 to 27 mm outside diameter	-

* *Basic HT pump only (see Section 3.5.3).*

† *Harting HT16B pump only (see Section 3.5.2).*

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2.7 Construction details

Table 7 - Construction consumables

Brazing	Silver solder (Ag 40.5%)
3CR12 welds	Bostrand 309L
M.I.G. brazing	Bostrand 200 aluminium bronze
TIG ALI welding	Saffire (5% Si)

Table 8 - Construction materials

Item	Material specification	Material description
Main body assembly	3CR12	11.5% chromium non-austenitic stainless steel; high-temperature paint finish
Interior assembly	LM25TF	Aluminium alloy machined castings.
	304S12/15	Stainless steel thermal shields and tie-rod.
	070M20 *	Mild steel tie-rod; nickel-plated.
Cooling-coils	HC101	High-conductivity copper, M.I.G. brazed to body assembly.
Electrical-box	CR1	Mild steel, high-temperature paint finish.
Radiation shield	304S12/15	Stainless steel, polished finish
Sight-glass gasket	-	Gore-tex ®
Inlet and outlet O-rings and Co-Seals	-	Nitrile or neoprene
Other O-rings and Co-Seals	-	Fluoroelastomer

* *HT20B pump only*

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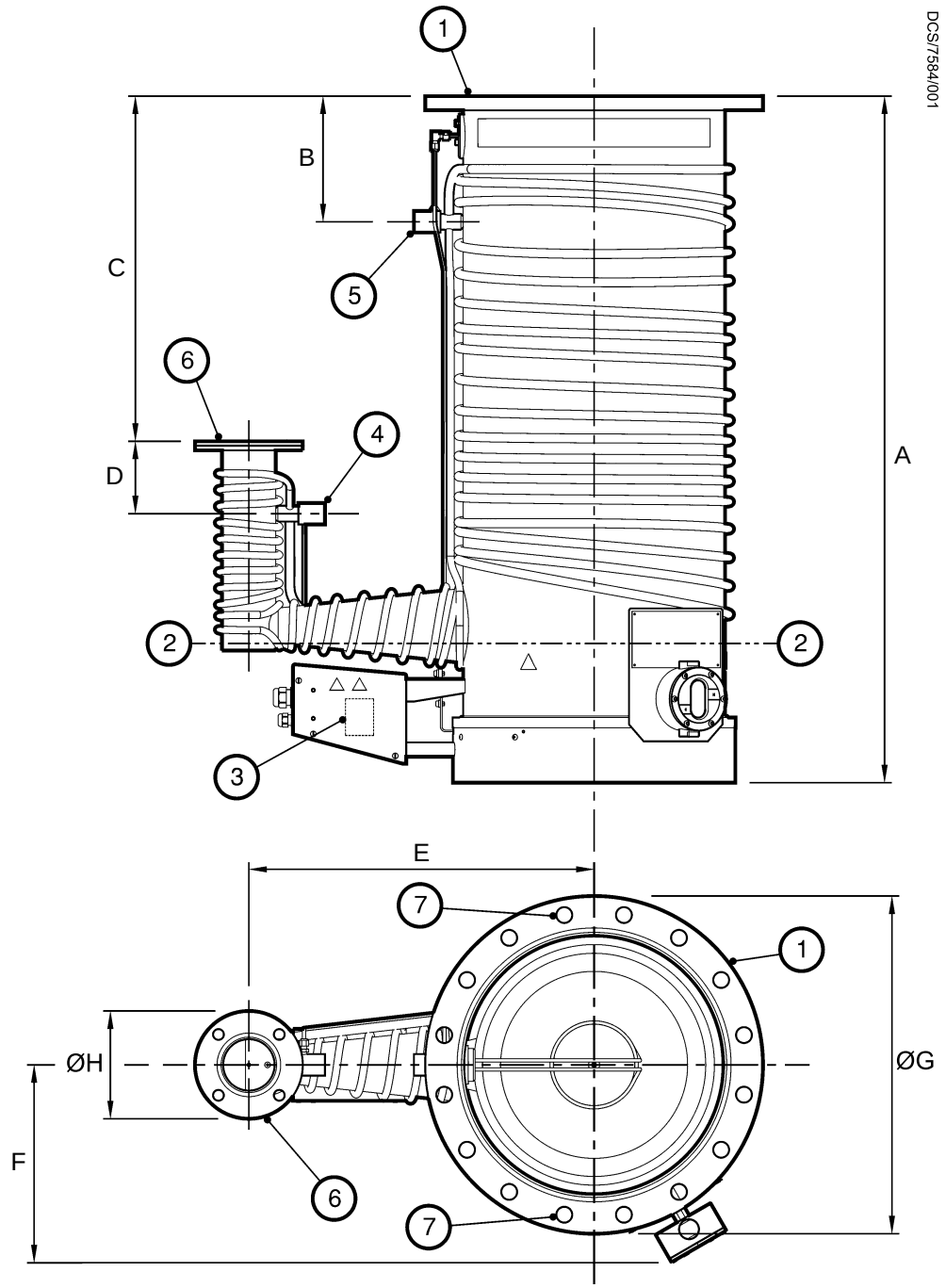
Figure 2 - Pump dimensions (mm)



1. Inlet
2. Surfaces below this line can reach temperatures of up to 250 °C
3. Identification and rating plate
4. Cooling-water outlet
5. Cooling-water inlet
6. Outlet
7. Lifting-bolt holes: Ø28 (ANSI pump only)

Key	HT16B	HT20B
A	1214	1302
B	222	250
C	610	584
D	128	158
E	610	635
F	323	N/A

Pump	ØG	ØH
HT16B ANSI	597	191
HT16B ISO	550	130
HT20B ANSI	699	229
HT20B ISO	690	180

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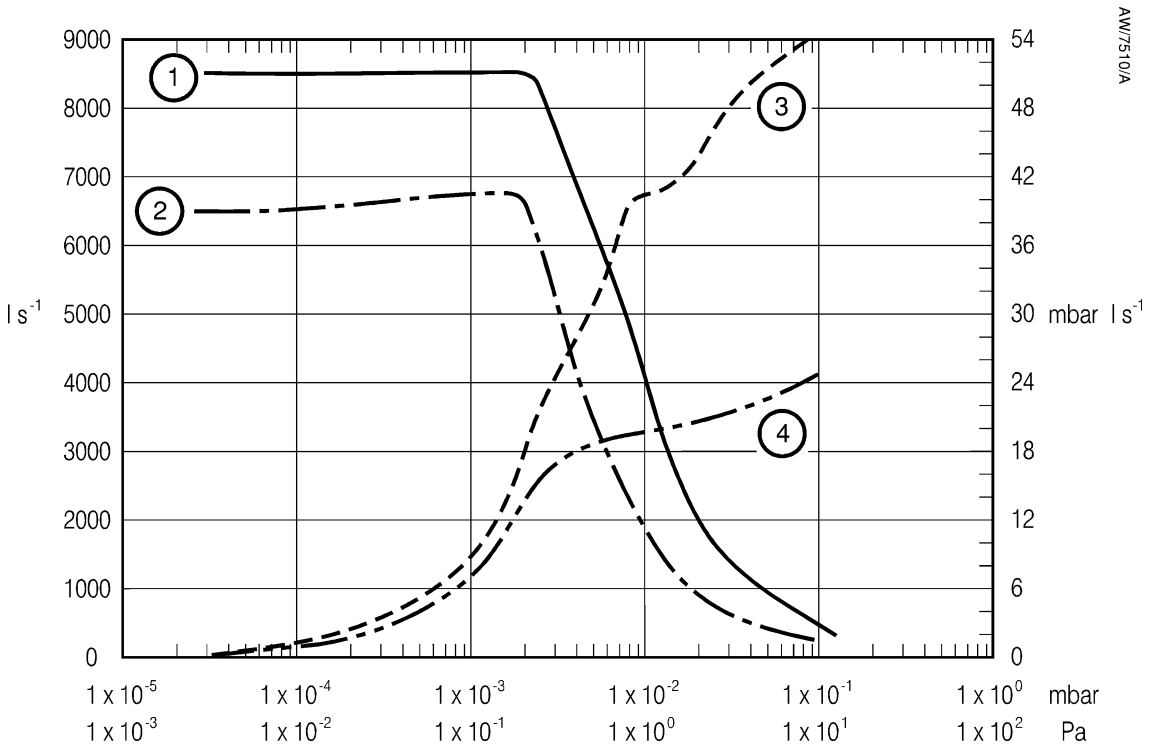
Figure 3 - HT16B performance curves



1. Pumping speed (l s^{-1}) plotted against pressure (mbar/Pa) for helium
2. Pumping speed (l s^{-1}) plotted against pressure (mbar/Pa) for nitrogen
3. Throughput (mbar l s^{-1}) plotted against pressure (mbar/Pa) for helium
4. Throughput (mbar l s^{-1}) plotted against pressure (mbar/Pa) for nitrogen

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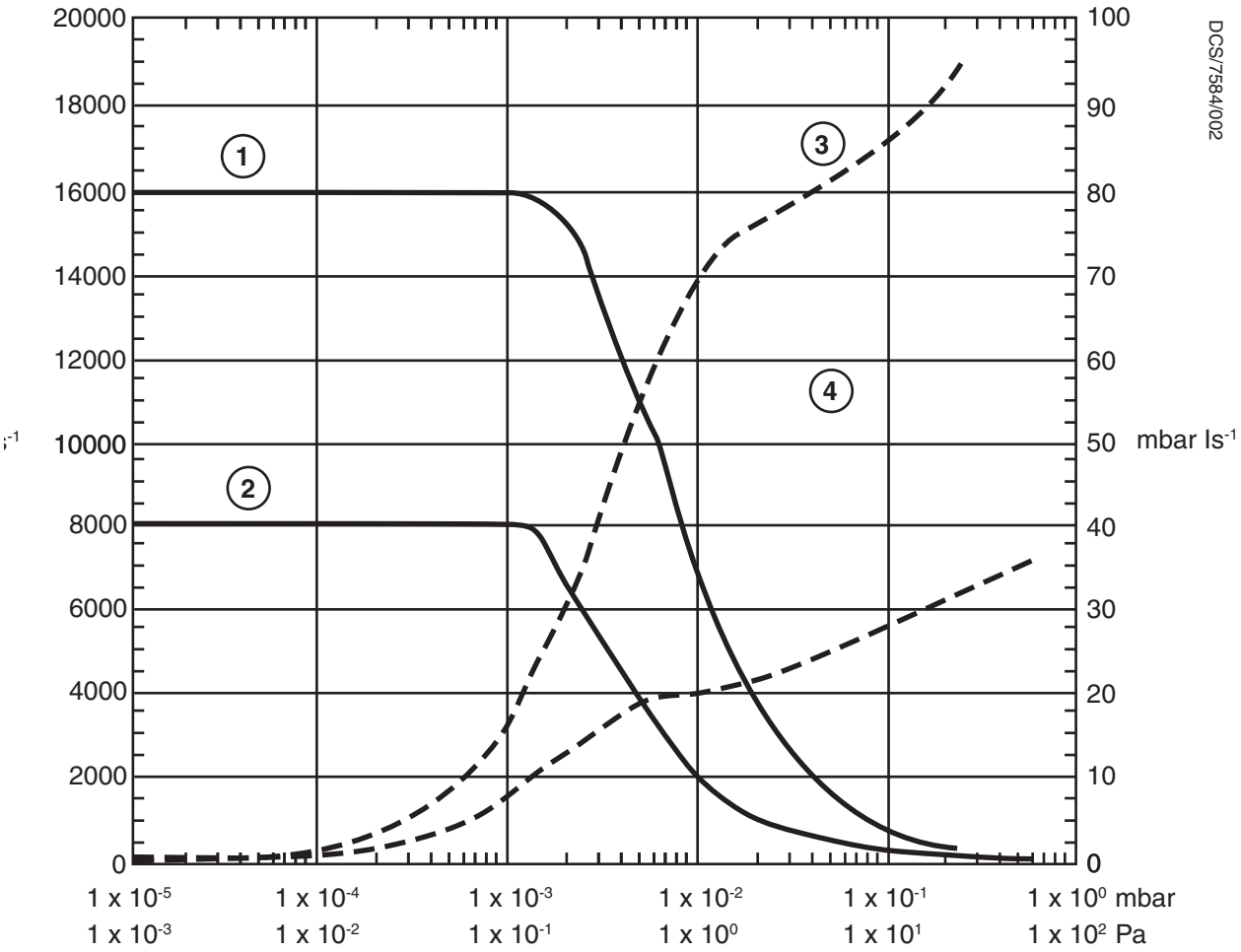
Figure 4 - HT20B performance curves



1. Pumping speed (l s^{-1}) plotted against pressure (mbar/Pa) for helium
2. Pumping speed (l s^{-1}) plotted against pressure (mbar/Pa) for nitrogen
3. Throughput (mbar l s^{-1}) plotted against pressure (mbar/Pa) for helium
4. Throughput (mbar l s^{-1}) plotted against pressure (mbar/Pa) for nitrogen

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3 Installation

3.1 Safety

WARNING

Obey the safety instructions given below and take note of appropriate precautions. If you do not, you can cause injury to people and damage to equipment.

- A suitably trained and supervised technician must install the pump.
- Isolate the other components in the vacuum system from the electrical supply before you start work.
- Use suitable lifting equipment when you move the pump.
- Ensure that the products handled by the pumping system are compatible with the materials of construction of the pump (see Section 2.7). If you have any doubts about the compatibility, contact your supplier or Edwards for advice.
- Do not use solvents to clean O-rings.
- Ensure that the installation technician is familiar with the safety precautions which relate to pump fluid and to the products handled by the pumping system. Wear the appropriate safety clothing when you come into contact with pump fluid or contaminated components. Dismantle and clean contaminated components inside a fume cupboard.
- Disconnect the other components of the vacuum system from the electrical supply so that they cannot be operated accidentally.
- Vent and purge the vacuum system with nitrogen for 15 minutes before you start installation work.

3.2 Unpack and Inspect

1. Remove all packing materials and protective covers and check the HT pump. If the pump is damaged, notify your supplier and the carrier in writing within three days; state the Item Number of the pump together with your order number and your supplier's invoice number. Retain all packing materials for inspection. Do not use the pump if it is damaged.
2. Check that your package contains the items listed in Table 9 (page 16). If any of these items is missing, notify your supplier in writing within three days.
3. Check that your electrical supply voltage corresponds to the voltage stated on the pump identification and rating plate (Figure 2, item 3). If the pump is not suitable for use with your electrical supply, do not continue to install and use the pump.

If the pump is not to be used immediately, refit the protective covers. Store the pump in suitable conditions, as described in Section 6.1.

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Table 9 - Checklist of items

Quantity	Description	Check (?)
1	HT Diffusion Pump	?
Fitting-kit, which contains the following:		
1	Inlet O-ring * or Co-Seal †	?
1	Outlet O-ring	?
Connector hood kit ‡, which contains the following:		
1	Hood	?
1	Hinged frame	?
2	Power crimp terminals (female)	?
1	Control crimp terminal (female)	?
6	6 mm^2 power crimp contacts (female)	?
6	4 mm^2 power crimp contacts (female)	?
2	1.5 mm^2 control crimp contacts (female)	?
1	PG29 cable clamp	?

* *ANSI pumps.*
† *ISO pumps.*
‡ *Harting HT16B pump only.*

3.3 Locate the pump

WARNING

Use suitable lifting equipment to move the pump, as described below. If you do not, you can injure yourself or damage the pump. Refer to Section 2.3 for the mass of the pump.

WARNING

If necessary, fit suitable guards or a heat shield to prevent accidental contact with the pump. During operation, surfaces of the pump are very hot and can cause injury to people.

CAUTION

Ensure that there is a clearance of at least 50 mm between the pump mounting feet and the nearest object/ surface, or mount the pump on a surface which can withstand temperatures up to 250 °C. Avoid contact between the pump and combustible materials, plastic materials and electrical cables. Surfaces of the pump are very hot and can cause damage to equipment.

3.3.1 General requirements

You must operate the pump with its inlet-flange horizontal and at the top. If the pump will be free-standing, you must support the backing pipeline to stabilize the pump.

Locate the pump at a practical distance from suitable electrical and cooling-water supplies (see Sections 3.5 and 3.6), and so that you can see the fluid-level sight-glass and can access the fluid fill port.

You must ensure that there are no exposed surfaces of the pump which are hotter than 100 °C. Where necessary, fit suitable guards.

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3.3.2 Installation on a vacuum system

1. Refer to Figure 1. Inspect the pump inlet (2) and outlet (8), O-rings and O-ring grooves and refinish if necessary: refer to Section 3.4.2.
2. Use a wide-track pallet truck or fork-lift to carefully move the pump (on its pallet) under its required operating location. Ensure that the pump does not topple when you move it.
3. Use the pallet truck or fork-lift to raise the pump until the inlet locates onto your vacuum system flange.
4. Secure the pump inlet to the vacuum system flange: refer to Section 3.4.2.
5. Lower the pallet clear of the pump.

3.3.3 Free-standing installation

1. Use a wide-track pallet truck or fork-lift to carefully move the pump (on its pallet) close to its required operating location. Ensure that the pump does not topple when you move it.
2. Attach suitable lifting equipment to the pump:
   - On pumps with ANSI flanges, fit suitable lifting bolts to the two lifting bolt holes (Figure 2, items 7) in the inlet flange, then attach suitable lifting equipment to the lifting bolts.
   - On pumps with ISO flanges, attach suitable slings to the pump under the inlet flange, then attach suitable lifting equipment to the slings.
3. Use the lifting equipment to lift the pump off of its pallet, and to move the pump into its required operating location.
4. Disconnect the lifting equipment from the pump.

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3.4 Vacuum connections

3.4.1 System design

WARNING

You must fit a backing pressure-interlock if you will use the HT to pump dangerous substances.

Consider the following points when you design your system:

- On all applications, we recommend that you fit a backing pressure-interlock to the outlet pipeline to switch off the electrical supply to the pump heaters if the pressure in the pipeline rises to the critical backing pressure.
- You **must** fit a backing pressure-interlock if you will use an HT to pump dangerous substances. If you do not fit a pressure-interlock and the pressure in the outlet pipeline rises to the critical backing pressure, fluid will backstream into the vacuum system and thermal breakdown of the pump fluid may occur. Note that if you have a suitable backing pressure gauge, you may be able to use the gauge to provide the necessary pressure signal for the pressure-interlock.
- Connecting pipelines should be as short as possible and have the largest possible diameter.
- Pipelines connected to the pump inlet and outlet must be self-supporting. Where this is not possible, ensure that the pipelines impose as small a load as possible on the inlet and outlet flanges.
- You must be able to vent the pump to atmosphere through the backing pipeline or the pump inlet. (You must **not** vent the pump through the boiler).
- Incorporate flexible pipelines in the backing pipeline to reduce the transmission of vibration and to prevent loading of coupling joints. If you use flexible pipelines, you must ensure that you use pipelines which have a maximum pressure rating which is greater than the highest pressure that can be generated in your system. We recommend that you use Edwards flexible pipelines.

3.4.2 Connect the pump inlet and outlet

WARNING

Conduct the outlet pipeline to a suitable treatment plant to prevent the discharge of dangerous gases and vapours to the surrounding atmosphere.

Note: *If your pump is not free-standing, you will have connected the inlet in Section 3.3.2.*

Refer to Figure 1. Use the O-rings supplied with the pump to fit the inlet-flange (2) and the outlet-flange (8) to your vacuum and exhaust system pipelines. Take note of the following recommendations:

- Inspect and thoroughly clean the O-rings and the O-ring grooves before you connect the pump. When you place O-rings, make sure that they are not twisted.
- To ease installation, coat the O-rings with a light film of the pump fluid.
- Before you fit the pump to the system, ensure that all sealing-faces are clean and scratch-free; refinish these faces if necessary.
- Use the correct number and size of bolts to connect the pump to your vacuum system.
- The pump is tested with DC704EU fluid before delivery. Internal surfaces of the pump are therefore covered with a thin film of DC704EU fluid. (Pumps ordered for use with alternative fluids will be tested with the alternative fluid.) Use acetone or another suitable cleaning solution to clean the pump flanges before you connect the pump to your vacuum system.

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3.5 Electrical connections

3.5.1 Introduction

WARNING

A competent electrician must do the electrical installation and maintenance of the pump.

WARNING

Ensure that the electrical installation of the pump conforms with your local and national safety requirements. The pump must be connected to a suitably fused and protected electrical supply and a suitable earth (ground) point.

WARNING

Make the electrical connections as described in this section and in Section 3.5.2 or 3.5.3. If you do not, the pump may not operate safely, and will not comply with the requirements of BS EN60204-1.

Note: *The operating temperature and the position of the thermal snap-switches on the HT pumps are factory set for use with DC704EU fluid. If you want to use other fluid types, please contact your supplier or Edwards for advice.*

The Harting HT16B pump is supplied with an electrical connector. You must use this connector to connect the thermal snap-switches to the pump control circuit, and to connect the pump to the electrical supply, as described in Section 3.5.2.

On the basic HT, you must use the terminals in the electrical box to connect the thermal snap-switches to the pump control circuit, and to connect the pump to the electrical supply, as described in Section 3.5.3.

Make the electrical connections to the pump as described in Section 3.5.2 or 3.5.3. Figures 5 and 6 show schematic diagrams of the recommended electrical circuit for correct operation and shut-down of the pumps.

Note that:

- You must connect your electrical supply to the pump through a suitable contactor. The contactor must incorporate an over-current trip, set in accordance with the requirements given in Section 2.6.
- Use electrical supply cable which is suitably rated for the total heater loading of the pump.
- Use suitable sized cables (see Table 6), for the cable-glands fitted to the pump (see Table 3).
- You must provide a suitable cable restraint and strain relief.

For additional electrical safety:

- We recommend that you connect the electrical supply to the pump through an RCCB (residual current circuit breaker): the RCCB will operate to disconnect the electrical supply if the insulation resistance of the heaters is too low. (As described in Section 1.4, when the pump is switched off, the heaters in the pump will absorb moisture: this will cause a decrease in the insulation resistance of the heaters.)
- We recommend that you fit an off-load isolator and an emergency stop switch for additional electrical safety.
- If you do not use conduit, use cable which is heat resistant (up to 250 °C) in case of accidental contact with the pump.

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Figure 5 - Recommended HT16B control circuit

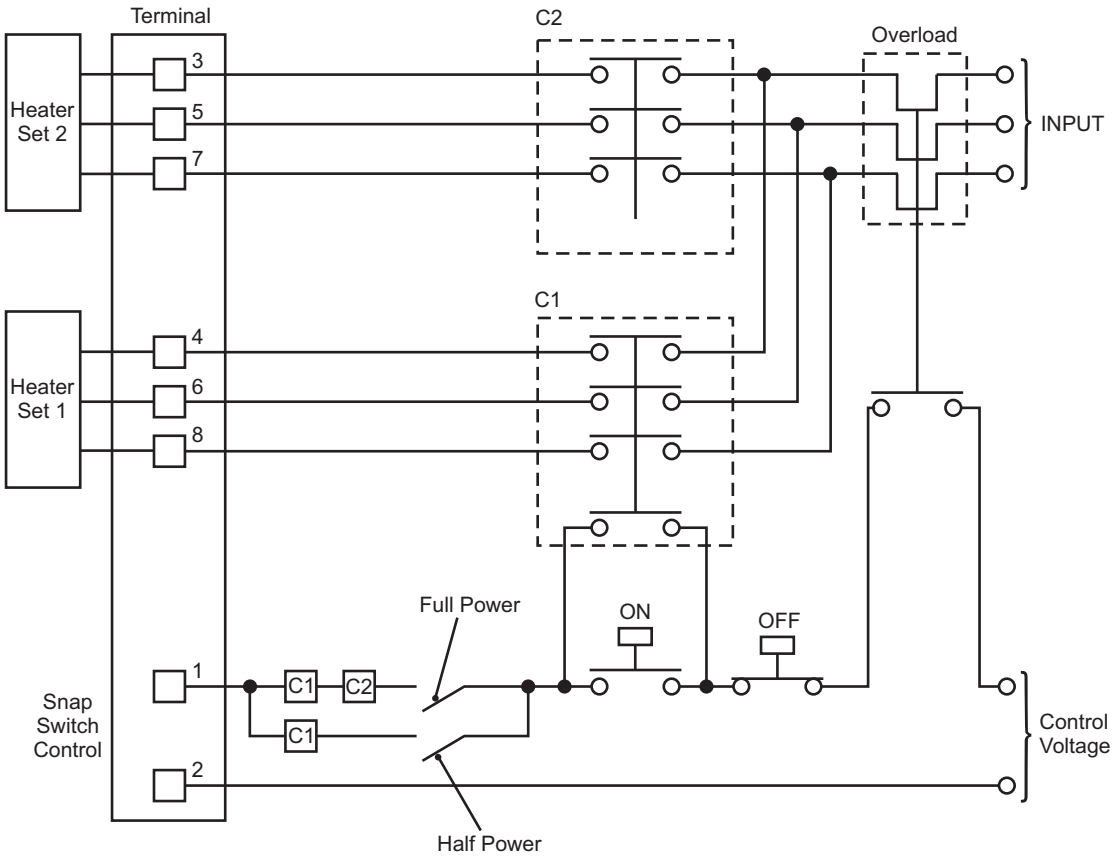

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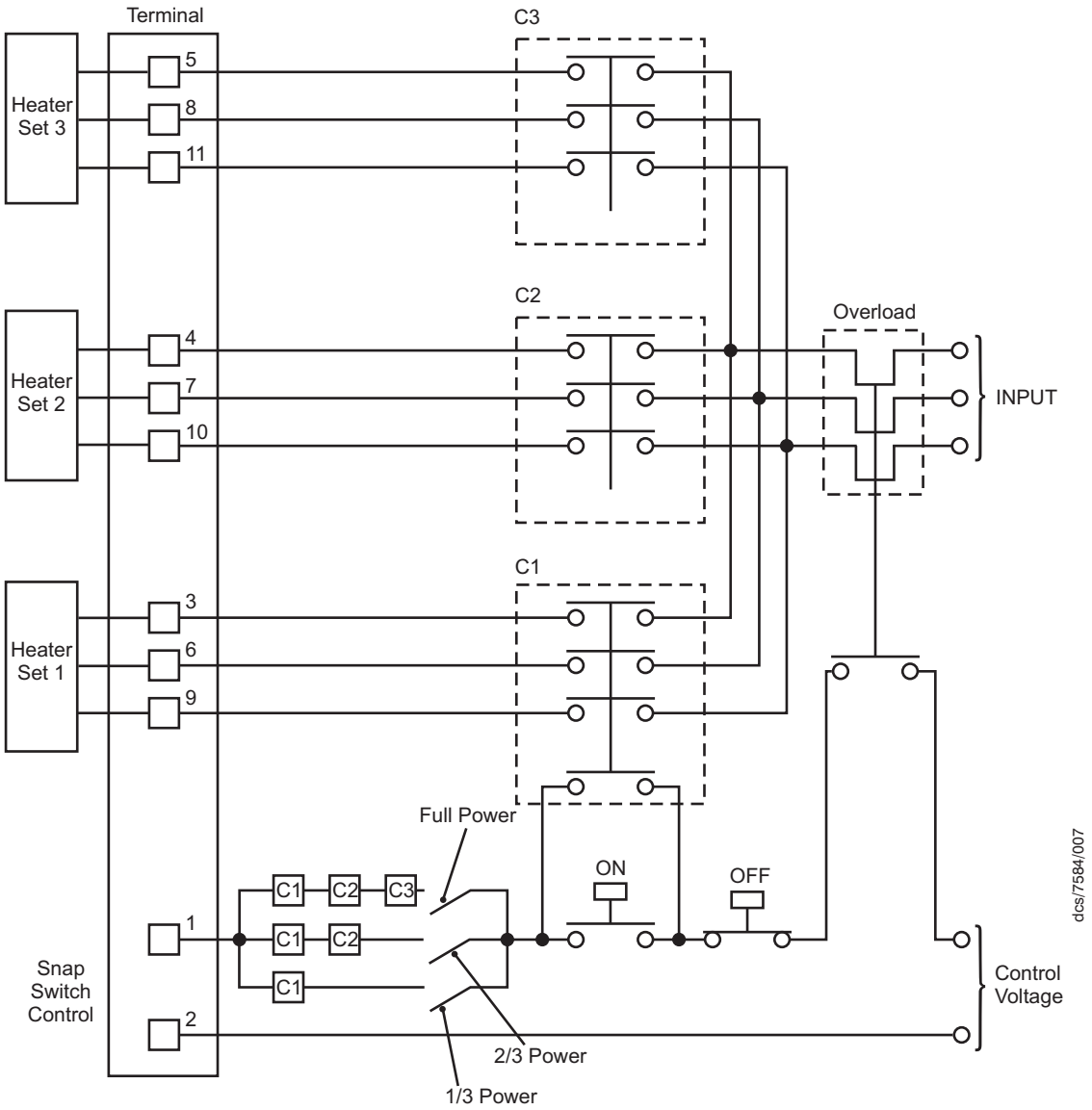
Figure 6 - Recommended HT20B control circuit



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3.5.2 Make the electrical connections (Harting HT16B pumps)

WARNING

You must connect the thermal snap-switches to your pump control circuit so that the electrical supply to the pump is switched off if either of the thermal snap-switches open. If you do not, the pump may overheat and be damaged and the pump fluid may undergo thermal breakdown.

The HT pump has a half-power (standby) mode facility. Two electrical supply cables therefore need to be connected to the pump.

You must use suitable crimp tools, to crimp wires to the crimp contacts.

We also recommend that you have suitable crimp removal tools (which you may need to use if you fit a crimp contact into the wrong location in the terminal).

As supplied, the thermal snap-switches are wired (in series) to the electrical connector on the electrical box. Use the connector hood kit supplied to connect the thermal snap-switches to your control equipment (through a suitable 2-core or 3-core control cable), and to connect the pump to the electrical supply (through suitable 4-core electrical supply cables) as described in the following procedure; the recommended control circuit is shown in Figure 5. The supply and control cables must be rated in accordance with the requirements of Section 2.6.

1. Crimp the two 1.5 mm^2 control crimp contacts (female) to the ends of your two control wires.
2. Push the two crimp contacts into positions 3 and 4 of the control crimp terminal (female).
3. Crimp three power crimp contacts (female) to each of the three phase conductors of your two electrical supply cables: use either the six 4 mm^2 power crimp contacts, or the six 6 mm^2 power crimp contacts.
4. Push the three power crimp contacts on one of the supply cables into positions 1, 2 and 3 of one of the power crimp terminals (female).
5. Push the three power crimp contacts on the second supply cable into positions 1, 2 and 3 of the second power crimp terminal (female).
6. Locate the power crimp terminals and the control crimp terminal in the hinged frame.
7. If your control cable has an earth (ground) wire, connect the wire to the 1 to 2.5 mm^2 screw terminal on the hinged frame.
8. Connect your system earth (ground) wire to the 4 to 6 mm^2 screw terminal on the hinged frame.
9. Screw the hinged frame assembly into the hood.
10. Fit your conduit to the hood. Alternatively, if you do not fit conduit, fit the PG29 cable clamp supplied to the connector hood, to provide strain relief for the cables.

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3.5.3 Make the electrical connections (basic HT pumps)

WARNING

You must connect the thermal snap-switches to your pump control circuit so that the electrical supply to the pump is switched off if either of the thermal snap-switches open. If you do not, the pump may overheat and be damaged and the pump fluid may undergo thermal breakdown.

The basic HT pumps have three links which connect the two sets of pump heaters. You must remove these three links if you want to operate the pump in half-power (standby) mode.

Use the following procedure to connect the electrical supply to your pump:

1. Refer to Figure 1 for the location of the electrical box. Support the base tray while you undo and remove the six screws on both sides of the electrical box.
2. Lower the base tray so that you can access the terminals in the electrical box.
3. Refer to Figure 7. Pass your main electrical supply cable (and your secondary electrical supply cable, if applicable) through the PG21 cable-gland.
4. Pass your control circuit cable through the PG11 cable-gland.
5. Connect the earth (ground) wire in your main electrical supply cable to the first earth (ground) terminal (4), marked "PE".
6. Connect the three phase wires in your main electrical supply cable to the electrical supply terminals (1) marked "3", "5" and "7".
7. If you want to operate the pump in half-power (standby) mode:
   - Remove the three links (2).
   - Connect the three phase wires in your secondary electrical supply cable to the electrical supply terminals (1) marked "4", "6" and "8".
   - Connect the earth (ground) wire in your secondary electrical supply cable to the second earth (ground) terminal (4).
8. Connect your control circuit wires to the auxiliary terminals (6) marked "1" and "2".
9. Raise the base tray back into position, then refit and tighten the six screws on both sides of the electrical box.
10. Tighten the strain-relief screws on the PG21 and PG11 cable-glands.

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3.6 Cooling-water connections

WARNING

Do not fit quick-fit couplings to the pump cooling-water inlet and outlet. Use of these couplings can result in trapped volumes of water. This water may boil, the cooling-coils may fracture and hot water and steam ejected from the cooling-coils may injure people.

CAUTION

Make sure the cooling-water flows in the correct direction. If it does not, there will be increased backstreaming and loss of performance, which may have an adverse effect on your process.

The minimum cooling water flow given in Section 2.5 is calculated for a 15 °C temperature rise. Thus, with a high water inlet temperature, it may be necessary to increase the flow to maintain the outlet temperature below 35 °C.

Do not exceed this temperature, otherwise a thermal snap-switch may operate to switch off the pump, and fluid loss to the backing pipeline will increase.

Use the formula below to calculate the minimum required cooling-water flow for the pump:

$$F = (3600 \times 0.9 \times P_h) \ / \ [4200 \times (35 - T_w)]$$

where:

- F is the minimum required cooling-water flow (in l h^{-1}).
- P_h is the heater power (in W).
- T_w is the cooling-water supply temperature (in °C).

Note: *The formula given above applies to cooling-water without additives: see Section 1.5.*

Note that:

- 90% of heater input power is transferred to the water supply (the balance is lost as radiant heat from the pump surfaces)
- The cooling-water used must contain no additional additives that may affect its cooling properties.
- The outlet temperature must be no higher than 35 °C
- The calculated value gives an absolute minimum water flow rate. We recommend that the water flow rate is at least 20% higher than this minimum flow rate.

High cooling-water temperatures should not have any appreciable effect on pump performance except to increase the vapour pressure of the fluid, which will limit the ultimate vacuum that can be obtained.

If your water supply temperature is 25 °C, you will need a flow of at least 700 l h^{-1} for the HT pump.

We recommend that the cooling-water supply is filtered and that a flow indicator is incorporated into the supply system.

Refer to Figure 1. Connect your cooling-water supply pipeline to the pump cooling-water inlet (4) and connect your return pipeline to the pump cooling-water outlet (6). Use $^3/_4$ inch NPT male fittings for the connections (these fittings are not supplied).

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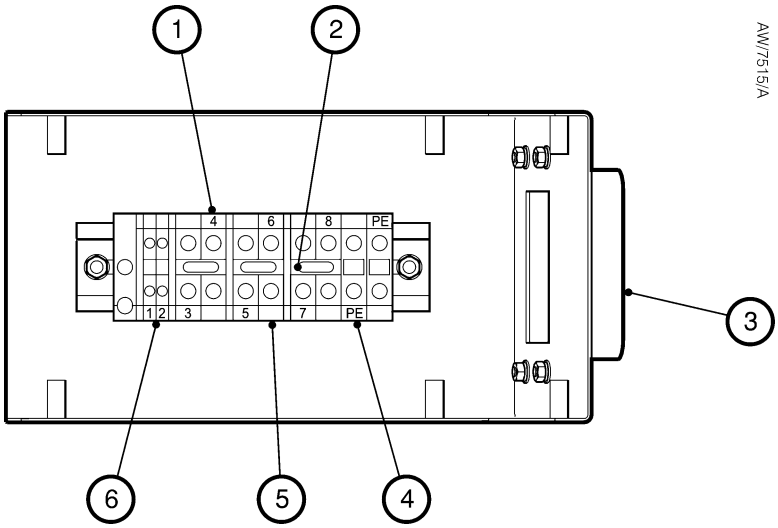
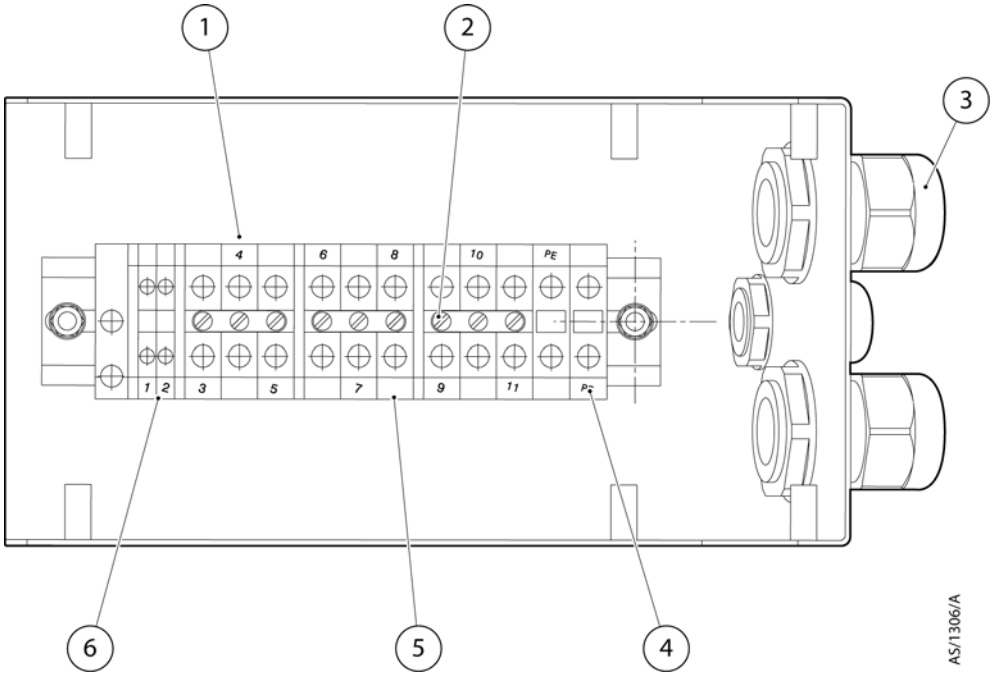
Figure 7 - HT16B electrical box



1. Electrical supply terminals (numbered)
2. Links *
3. Electrical connector †
4. Earth (ground) terminals
5. Heater connection terminals (not numbered)
6. Auxiliary terminals

* Basic HT pumps only; not fitted to Harting HT16B pumps.
† Harting HT16B pumps only. A cable-gland is fitted to basic HT pumps.

Figure 8 - HT20B electrical box



1. Electrical supply terminals (numbered)
2. Links
3. Electrical connector
4. Earth (ground) terminals
5. Heater connection terminals (not numbered)
6. Auxiliary terminals

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3.7 Leak-test the system

The HT pumps are stringently leak-tested before despatch. After you have installed the pump, leak-test the system before you fill the pump with pump fluid, and seal any leaks found; outgassing from the fluid may give false test results. The pump fluid is viscous at ambient temperatures and may block small leaks.

The level of leak tightness required will depend on the application of your system. You must leak-test the system to ensure the integrity of your vacuum system and its vacuum seals.

3.8 Fill the pump with fluid

3.8.1 Safety of vapour pump fluids

Vapour pump fluids are not dangerous when used in a pump that is operated correctly. But if the pump is operated incorrectly and is allowed to get to very high temperatures, the pump fluid can go through a process of thermal breakdown. The breakdown products which result can be dangerous.

Table 10 gives more information about the thermal breakdown of the different vapour pump fluids. Thermal breakdown is more likely to occur if the breakdown temperature is close to the operating temperature of your pump.

Ensure that you comply with the following general safety recommendations when you handle or use vapour pump fluids:

- Store pump fluids away from heat and naked flames.
- Keep fluid containers closed when not in use.
- Prevent spills and minimise operations that will contaminate the working areas and equipment.
- Use suitable absorbent materials to mop up small spills, and dispose of the materials as described in Section 6.2.
- Keep eyewash bottles filled with water readily available. Use these bottles to immediately flush the eyes if contaminated with pump fluid.
- Minimise exposure to the pump fluid. Wear suitable protective clothing, such as impervious gloves, apron, boots and so on. Avoid prolonged and repeated contact with pump fluid.
- Do not put on heavily contaminated items of clothing or protective equipment until they have been laundered or decontaminated.
- Wash your hands with soap and water before eating or smoking, before using toilet facilities and before leaving work.

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3.8.2 Recommended pump fluids

WARNING

Do not use perfluoropolyether (PFPE) pump fluids in the HT pump. The thermal breakdown temperature of PFPE fluids is near to the operating temperature of the pump. The thermal breakdown products of PFPE fluids are very dangerous.

Use a silicone fluid (for example, DC704EU) in the HT pumps.

The thermal breakdown products of some fluids can be dangerous; details of the breakdown products are given in Table 10. The pump has a protection system which prevents the pump from reaching temperatures at which this thermal breakdown occurs.

Table 10 - Vapour pump fluid thermal breakdown

Vapour pump fluid	Edwards Product	Auto-ignition Temp. °C	Break-down Temp. °C	Thermal breakdown products	Type of danger	Possible injury
Silicone fluids (methyl phenyl siloxanes)	DC702, DC704EU, DC705	≈ 500	400	Decomposed hydrocarbons and silicon based species	Negligible	Negligible
Alkyl naphthalene fluid	Edwards L9	70	≈ 300	Naphthalene and decomposed hydrocarbons	Naphthalene is poisonous in large quantities by ingestion and skin contact	Minor (first aid may be required)
Polyphenyl ether (5-Ring)	Santovac® 5	590	≈ 480 (in helium)	Phenol, benzene & phenolic materials	Phenolic materials are poisonous & caustic by ingestion and skin contact	Major (a lost time accident can occur)
Paraffinic fluids & ester fluids	Apiezon® A, B, C, AP201 and AP301	≥ 305	< 300 (in air)	Decomposed hydrocarbons	Fire (Note: AP201 has a low auto-ignition temperature)	Major (a lost time accident can occur)
Perfluoro-polyether	None	None	> 260	Decomposed fluorocarbons including hydrofluoric acid	Highly aggressive materials. Poisonous and caustic by inhalation and skin contact.	Potentially fatal

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3.8.3 Filling procedure

WARNING

Ensure that the fluid-level in the pump is correct: the fluid-level should be just below the maximum mark on the bezel of the sight-glass. If the fluid-level falls below the minimum mark on the bezel, the pump will overheat during operation and may be damaged, and the pump fluid may undergo thermal breakdown.

When you fill the pump:

- Use the best fluid for your application.
- When you first receive the pump, its internal surfaces will be coated with a thin film of DC704EU fluid. This fluid is used to test the pump before dispatch. You must clean the pump before you fill it with a fluid other than DC704EU.
- You can refill the pump with the fluid which you last used in the pump. If you want to use a different fluid, you must clean the pump thoroughly before you refill the pump.

Use the following procedure to fill the pump with fluid:

1. Refer to Figure 1. Fill the pump with the chosen fluid (see Section 2.4 for the fluid charges). Use one of the following methods:
   - Remove the fluid filler plug (43) and pour the fluid into the pump through the fill port.
   - Pour the fluid through the inlet-flange (2). Do not allow the fluid to flow onto the cool-cap assembly. The performance of the pump will be reduced if there is fluid on the cool-cap assembly.
2. Allow the fluid to drain into the pump for 5 minutes.
3. Look at the fluid-level shown in the sight-glass (46). The fluid-level is correct when it is just below the maximum mark on the bezel (41):
   - Add more fluid if the fluid-level is too low.
   - If the fluid-level is too high (that is, above the maximum mark on the sight-glass bezel, 41), drain the excess fluid (see Section 5.5).
4. If you have removed the fluid filler plug (43), refit it to the pump.

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4 Operation

4.1 Introduction

WARNING

Do not use the HT to pump flammable gases. If you do, this may result in an explosion or fire. (The interior of the pump can reach very high temperatures, and will remain hot after the HT is switched off, until the pump has cooled down.) If in doubt about the compatibility of gases with the use of the HT pump, contact Edwards for advice.

WARNING

Do not operate the pump when the cooling-water flow through the cooling-coils is restricted. If you do, water in the cooling-coils may boil, the cooling-coils may fracture, and hot water and steam which escapes from the cooling-coils may injure people.

WARNING

Do not touch any part of the pump when it is switched on. Avoid contact between the pump and combustible materials, plastic materials and electrical cables. Surfaces of the pump are very hot and can cause injury to people and damage to equipment.

WARNING

If the cooling-water supply fails, allow the pump to cool before you disconnect the cooling-water supply and return pipelines from the pump. If you do not, steam or water may be ejected from the cooling coil when you disconnect the pipelines and you may be injured.

WARNING

Do not expose any part of your body to vacuum. If you do, you may be injured.

Note: *The temperatures specified in the following sections were measured at the edge of the base flange of the HT pump (Figure 1, item 40). The temperatures and curves are therefore different from those specified for the Thermal Probe accessory in the HT Diffusion Pump Accessories instruction manual.*

Sections 4.3 to 4.5 describe the alternative operating procedures applicable to the system configurations shown in Figures 9, 10 and 11. Choose the procedure most suited to your vacuum system.

The following basic rules apply to all diffusion pump systems:

- Always turn on the cooling-water supply before you switch on the HT pump, otherwise the pump will overheat
- Always allow the HT pump to cool for at least 30 minutes before you turn off the cooling-water supply
- Never allow the pressure at the inlet of the HT pump to rise above 0.1 mbar (10 Pa) when the pump is at operating temperature
- When the pump is at operating temperature, never allow the backing pressure to rise above the critical backing pressure for the fluid used (see Section 2.2)
- Always allow the pump to cool for at least 90 minutes before the pump-inlet and backing pressures are allowed to rise above their critical values.

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4.2 Check the electrical safety of the pump

4.2.1 Check the earth (ground) continuity

Before you switch on the pump, you must check the continuity (resistance) between the earth (ground) stud on the pump and accessible metal surfaces of the pump.

We recommend that you check the resistance between the earth (ground) stud and several locations on the pump. Then:

- If all of the resistances are < 0.1 Ω: continue at Section 4.2.2.
- Otherwise, contact your supplier or Edwards for advice; do not continue to use the pump.

4.2.2 Check the insulation resistance of the heaters

If the heaters in the HT pump have absorbed moisture while the pump was switched off, the insulation resistance of the heaters may be too low. Use the following procedure to measure the insulation resistance of the heaters before you switch the pump on.

If you have an RCCB in your electrical supply circuit, you do not need to measure the insulation resistance of the heaters because the RCCB will operate to disconnect the electrical supply from the pump if the insulation resistance is too low. If your RCCB has operated, use the following procedure to check the insulation resistance of the heaters before you reset the RCCB.

1. Measure the insulation resistance (at 500 V d.c.) between any of the heater terminals (Figure 7, items 2) and earth (ground). Then:
   - Multiply the measured resistance by the number of heaters in the pump, to calculate the insulation resistance per heater.
   - If the insulation resistance per heater is greater than 1 MΩ, you can switch on the pump.
   - If the insulation resistance per heater is less than 1MΩ, continue at Step 2.
2. Remove the heaters from the pump (refer to Section 5.10.1). Bake the heaters in an oven at a temperature of 120 °C for 12 hours or more.
3. Remove the heaters from the oven. Measure the insulation resistance of each heater:
   - If a heater has an insulation resistance greater than 1 MΩ, you can refit the heater to the pump.
   - If a heater has an insulation resistance less than 1 MΩ, repeat Steps 2 and 3 of this procedure.
   - If the insulation resistance of a heater is less than 1 MΩ after the heater has been baked for 24 hours, then the heater is faulty and you must replace it with a new heater.

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4.3 Start-up

WARNING

If you have incorporated isolation valves in both the cooling-water supply and return pipelines, ensure that both valves are open before you switch on the pump. If you do not, water trapped in the cooling-coils may boil, the cooling-coils may fracture, and hot water and steam which escapes from the cooling-coils may injure people.

Note: *If you do not have an RCCB in your electrical supply circuit, you must check the insulation resistance of the heaters as described in Section 4.2.2 before you switch on the HT pump.*

4.3.1 Fully-valved pumping system

1. Refer to Figure 9. Close all valves and check that all other openings to atmospheric pressure are closed.
2. Turn on the cooling-water supply to the HT pump.
3. Switch on the backing/roughing pump (4).
4. Open the backing valve (6) and allow the HT pump to be pumped down through the backing pipeline to a pressure of less than 0.1 mbar (10 Pa).
5. When the pressure in the backing pipeline is less than 0.1 mbar (10 Pa), switch on the electrical supply to the HT pump heaters.
6. Allow sufficient time for the pump to heat up to operating temperature (approximately 80 minutes).
7. Close the backing valve (6), open the roughing valve (3) and pump down your vacuum system to a pressure of less than 0.1 mbar (10 Pa).
8. Close the roughing valve (3), immediately open the backing valve (6) and then open the high-vacuum isolation-valve (8) slowly; if you open the high-vacuum isolation-valve too quickly, you can stall the pump. Pump down the vacuum system to the pressure required.

4.3.2 Partially-valved pumping system

1. Refer to Figure 10. Close all valves and check that all other openings to atmospheric pressure are closed.
2. Turn on the cooling-water supply to the HT pump.
3. Switch on the backing pump (5).
4. When the pressure in the backing pipeline is less than 0.1 mbar (10 Pa), switch on the electrical supply to the HT pump heaters.
5. Switch on the roughing pump (4), open the roughing valve (3) and pump down your vacuum system to less than 0.1 mbar (10 Pa).
6. Allow sufficient time for the pump to heat-up to operating temperature (approximately 80 minutes).
7. Close the roughing valve (3) and then open the high-vacuum isolation-valve (7); if you open the high-vacuum isolation-valve too quickly, you can stall the pump. Pump down your vacuum system to the pressure required.

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4.3.3 Valveless pumping system

1. Refer to Figure 11. Close the air-admittance valve (2) and check that all other openings to atmospheric pressure are closed.
2. Turn on the cooling-water supply to the HT pump (4).
3. Switch on the backing pump (3).
4. When the pressure in your vacuum system is less than 0.1 mbar (10 Pa), switch on the HT pump heaters and pump down your system to the pressure required.

4.4 Process cycling

4.4.1 Introduction

In many applications, the HT pump may be run continuously except for maintenance periods. The backing pump must run continuously while the HT pump is at operating temperature to maintain the critical backing pressure.

A high-vacuum isolation-valve as shown in Figures 9 and 10 is needed to isolate the pump from your vacuum system between process cycles.

If you have suitably configured the pump as described in Section 3.5, while the pump is isolated from your vacuum system, you can select ‘half-power‘ operation to reduce electrical power consumption. To select ‘half power’ operation, switch off one of the electrical supplies connected to the pump.

When ‘half power’ operation is selected, the vacuum pressure above the pump inlet will be maintained, however pumping speed and throughput are reduced. You should therefore switch the pump to full power operation for at least 15 minutes before you open the high-vacuum isolation- valve and resume process pumping.

4.4.2 Re-admission of air to your vacuum system

WARNING

Do not admit air into the pump through the filler plug port or through any other port until the pump has cooled to ambient temperature. If you do, the pump fluid may ignite, or expansion of admitted air can cause hot fluid to be ejected from the pump.

On valveless pumping systems, use the shutdown procedure in Section 4.5.4.

On valved pumping systems only, close the high-vacuum and roughing valves and open the chamber air-admittance valve.

4.4.3 Re-evacuate your vacuum system

On valveless pumping systems use the start-up procedure in Section 4.3.3.

On valved pumping systems only, use the following procedure:

1. Close the air-admittance valve(s) and any other openings to atmospheric pressure.
2. Open the roughing valve and pump down your vacuum system to less than 0.1 mbar (10 Pa).
3. Close the roughing valve.
4. Open the high-vacuum valve slowly; if you open the valve too quickly, you can stall the HT pump.

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Figure 9 - Fully-valved pumping system

1. Vacuum system
2. Vacuum system air-admittance valve
3. Roughing valve
4. Backing/roughing pump
5. Backing pump air-admittance valve
6. Backing valve
7. HT pump
8. High-vacuum isolation-valve

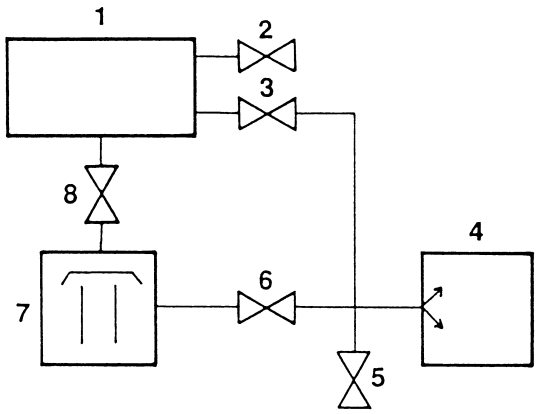


Figure 10 - Partially-valved pumping system

1. Vacuum system
2. Vacuum system air-admittance valve
3. Roughing valve
4. Roughing pump
5. Backing pump
6. HT pump
7. High-vacuum isolation-valve
8. HT pump air-admittance valve

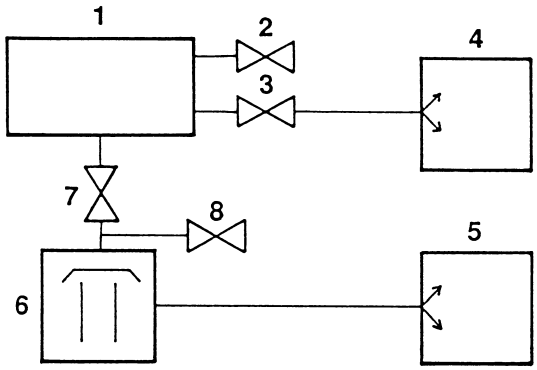
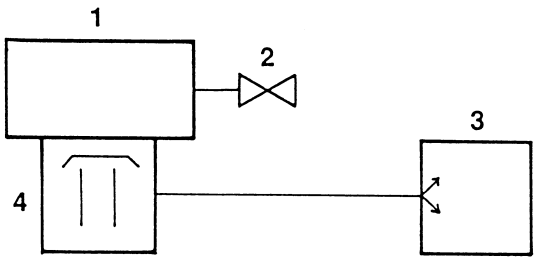


Figure 11 - Valveless pumping system

1. Vacuum system
2. Air-admittance valve
3. Backing pump
4. HT pump



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4.5 Pump shut-down

4.5.1 Introduction

Use the procedures in Sections 4.5.2 to 4.5.4 to shut down the pump.

As described in Section 1.4, when the HT pump is switched off, the heaters in the pump will absorb moisture: this will cause a decrease in the insulation resistance of the heaters.

To avoid the absorption of moisture when the pump is in an environment of high ambient humidity, we recommend that you maintain the base flange temperature at a temperature between 20 and 30 °C above ambient temperature. Ensure that the base flange does not get too hot; if it does, the pump fluid may vaporise and contaminate the vacuum system.

For more information about the operation of the pump in high ambient humidity, request a copy of our Application Note P400-50-000 from your supplier or Edwards.

If you have incorporated isolation valves in both the cooling-water supply and return pipelines:

- If you are going to shut down the pump in order to carry out maintenance, you must close both of the water isolation valves.
- If you are not going to carry out maintenance, but are only going to shut down the pump in between process pumping operations, we recommend that you only close one of the water isolation valves.

This will minimise the chance that the pump can subsequently be operated with both water isolation valves closed: see the WARNING at the start of Section 4.3.

4.5.2 Fully-valved pumping systems

WARNING

Do not admit air into the pump through the filler plug port or through any other port until the pump has cooled to ambient temperature. If you do, the pump fluid may ignite, or expansion of admitted air can cause hot fluid to be ejected from the pump.

The following method of shut-down of a fully-valved pumping system ensures that the HT pump is left evacuated and so prevents absorbtion of air by the pump fluid. When you subsequently start-up, pump down the system through the roughing pipeline to a pressure of less than 0.1 mbar (10 Pa) before you open the backing valve.

1. Refer to Figure 9. Close the high-vacuum isolation-valve (8).
2. Switch off the HT pump heaters and allow the pump to cool for at least 90 minutes. If you do not allow the pump to cool before you admit air, on re-evacuation the pump fluid will superheat and evolve vapour which will pass into the backing pipeline.
3. Close the backing valve (6), then switch off the backing/roughing pump (4).
4. Open the backing pump air-admittance valve (5). If you do not admit air to the backing pump, backing pump oil may be drawn into the backing pipeline.
5. When the HT pump has cooled completely, turn off the cooling-water supply.
6. If required, open the vacuum system air-admittance valve (2) to admit air into the system.

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4.5.3 Partially-valved pumping systems

WARNING

Do not admit air into the pump through the filler plug port or through any other port until the pump has cooled to ambient temperature. If you do, the pump fluid may ignite, or expansion of admitted air can cause hot fluid to be ejected from the pump.

To shut down a partially-valved pumping system, use the procedure below.

1. Refer to Figure 10. Close the high-vacuum isolation-valve (7).
2. Switch off the HT pump heaters and allow the pump to cool for at least 90 minutes. If you do not allow the pump to cool before you admit air, on re-evacuation the pump fluid will superheat and evolve vapour which will pass into the backing pipeline.
3. Switch off the backing pump (5).
4. Open the HT pump air-admittance valve (8). If you do not admit air to the system, backing pump oil may be drawn into the backing pipeline.
5. When the HT pump has cooled completely, turn off the cooling-water supply.
6. If required, open the vacuum system air-admittance valve (2).

4.5.4 Valveless pumping systems

Refer to Figure 11 and use the procedure below to shut down a valveless pumping system.

1. Switch off the HT pump heaters and allow the pump to fully cool.
2. Switch off the backing pump (3).
3. Open the air-admittance valve (2). If you do not admit air into the vacuum system, backing pump oil may be drawn into the backing pipeline.
4. When the HT pump has cooled completely, turn off the cooling-water supply.

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5 Maintenance

5.1 Safety

WARNING

Obey the safety instructions given below and take note of appropriate precautions. If you do not you can cause injury to people and damage to equipment.

- A suitably trained and supervised technician must maintain the HT pump.
- Ensure that the maintenance technician is familiar with the safety procedures which relate to the pump fluid and the products pumped. Wear the appropriate safety-clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume-cupboard.
- Isolate the HT pump from the electrical supply and your vacuum system before you start maintenance work.
- Allow the HT pump to cool fully before you touch any part of the pump (including the fluid filler plug and the fluid drain plug) or attempt to move it. Open the pump to atmospheric pressure when it is cool.
- Always allow the HT pump to cool for at least 30 minutes before you turn off the cooling-water supply.
- Do not remove the fluid filler plug or the fluid drain plug to vent the HT pump while the pump is operating or under vacuum.
- Ensure adequate lighting during service.
- Use suitable lifting equipment when you move the pump (refer to Section 2.3 for the mass of the HT pump).
- Do not touch or inhale the thermal breakdown products of fluorinated materials which may be present if the HT pump has been overheated to 315 °C and above. These breakdown products are very dangerous. Fluorinated materials in the pump may include seals and O-rings. The pump may have overheated if it was misused, if it malfunctioned or if it was in a fire. Edwards Material Safety Data Sheets for fluorinated materials used in the pump are available on request; contact your supplier or Edwards.
- Do not touch or inhale the thermal breakdown products of the pump fluid if the HT pump has been overheated.
- Do not use abrasive or reactive chemical substances to clean the HT pump.
- Do not use solvents to clean O-rings.
- If you need to work under the pump, wear suitable protective clothing, eye protection and breathing apparatus.

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5.2 Tools and equipment required

You will need the following tools and equipment to carry out the maintenance operations described in the following sections:

- Lifting equipment (hoist or crane)
- Set of metric spanners
- Cross-head screwdriver
- Adjustable wrench
- Paraffin based cleaning solution
- Abrasive pads
- Lint free wipes
- Torque wrench with 24 mm socket

5.3 Maintenance plan

The plan shown in Table 11 below lists the maintenance operations necessary to maintain the HT pump in normal use. Instructions for each operation are given in the section shown.

More frequent maintenance may be required if the HT pump has been used to process corrosive or abrasive gases and vapours. If necessary, adjust the maintenance plan according to your experience.

Table 11 - Maintenance plan

Operation	Frequency	Refer to Section
Check the pump fluid-level	Monthly	5.4
Inspect the pump fluid and drain if necessary	Monthly	5.5
Clean the pump	Yearly	5.6
Clean the cooling-coil	Yearly	5.7
Inspect the heater wires and replace if necessary	Yearly	5.8
Replace the thermal snap-switches	As required	5.9
Replace a heater	As required	5.10

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5.4 Check the pump fluid-level

If the HT pump boiler operates at a higher than normal temperature, check the level of fluid in the pump boiler as described below.

1. Refer to Figure 1. Look at the fluid-level sight-glass (46). If the fluid-level is low (that is, close to or below the minimum mark on the sight-glass bezel, 41), continue at Step 2 below.
2. Switch off the pump, allow it to cool, and then open it to atmospheric pressure.
3. Remove the fluid filler plug (43) and pour new fluid into the pump through the fill port.
4. Allow the fluid to drain into the boiler and check the level again:
   - If the fluid is still too low, add more fluid.
   - If the level is too high (that is, above the maximum mark on the sight-glass bezel, 41), drain the excess fluid: see Section 5.6.
5. Refit the fluid filler plug (43) to the pump.

5.5 Inspect and drain the pump fluid

If the HT pump fails to give satisfactory performance on a leak tight system, inspect the condition of the pump fluid as described below.

1. Allow the HT pump to cool and open it to atmospheric pressure.
2. If the pump is cold, switch on the pump heater for a maximum of two minutes to warm the pump fluid to aid draining. Do not vaporise the pump fluid.
3. Refer to Figure 1. Remove the fluid drain-plug (44) and allow the fluid to drain from the pump.
4. Disconnect the pump from the electrical supplies and detach it from your vacuum system.
5. Visually check the interior of the pump:
   - If it is badly discoloured or coated with charred fluid, the pump fluid has deteriorated and must be changed; clean the pump as described in Section 5.6.2.
   - If the fluid is in a satisfactory condition, refill the pump as described in Section 3.8 and refit it to the system.

5.6 Clean the pump

5.6.1 Introduction

WARNING

Remove all traces of the cleaning solution before you operate the HT pump. If you do not, there may be a risk of fire or explosion.

When you clean the HT pump, choose the cleaning solution to suit the type of pump fluid that has been used.

Note that the pump body assembly and all of the components (excluding all electrical items) can be vapour de-greased, but we do not recommend this, as prolonged immersion can damage the external painted finish.

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5.6.2 Dismantle the pump

WARNING

Use suitable lifting equipment to move the pump or heavy components/assemblies of the pump. If you do not, you can injure yourself or damage the pump. Refer to Section 2.3 for the mass of the pump.

1. Drain the pump fluid as described in Section 5.6.
2. Isolate the pump from the electrical supply.
3. Refer to Figure 1. Disconnect the cooling-water supply and return pipelines from the cooling-water inlet (4) and outlet (6), and drain the cooling-water from the pump.
4. Remove the three cool-cap mounting screws (32).
5. Remove the fixing screw, special washer and ceramic washer (26 to 28) in the centre of the cool-cap (24) and lift the assembly clear of the pump. Take care not to displace the O-ring (34) when you remove this assembly.
6. Remove the ceramic spacer (29) from the top-jet cap (30).
7. Remove the secondary-cap (25).
8. Remove the three fixing screws and the top-jet cap (30) from the top of the interior assembly.
9. Remove the interior tie-rod (19), then remove the fixing bolt, spring and washer assembly (23) from the tie-rod.
10. Lift out the remaining jet stages (22, 20, 18 and 17: see Note below), the centre tube (15), the fluid drier assembly (14) and the thermal shields (38, 39).

Note: *Refer to Figure 12 (page 41). Note that the mass of the lower stage (3) is 12 kg. To assist removal of the lower stage (and to avoid having to lean into the pump), we recommend that you use a lifting bar (1); fit the lifting bar under the rim (2) of the lower stage, then attach suitable lifting equipment to the lifting bar and lift the lower stage from the pump.*

You must make your own lifting bar out of suitable materials; the bar should be 345 to 375 mm long, with a maximum width of 70 mm.

5.6.3 Clean the pump components

1. Wash the pump interior and internal components with the selected cleaning solution.
2. Wash again in acetone to remove all traces of the solution. Bake to 77 °C to remove the acetone. Alternatively, pass warm air over the components and the pump interior.
3. Refer to Figure 1. Inspect the outlet baffle assembly (7). If the pump has been used in heavily contaminated processes, it may be necessary to clean the baffle assembly as described above.
4. Inspect all of the O-rings; replace any that are damaged or that have undergone thermal set. Use dry, lint-free cloth or paper to clean the undamaged O-rings. Ensure that all O-rings are dust-free before reassembly.
5. Check that all sealing-faces are scratch-free. Refinish surfaces that are scratched.

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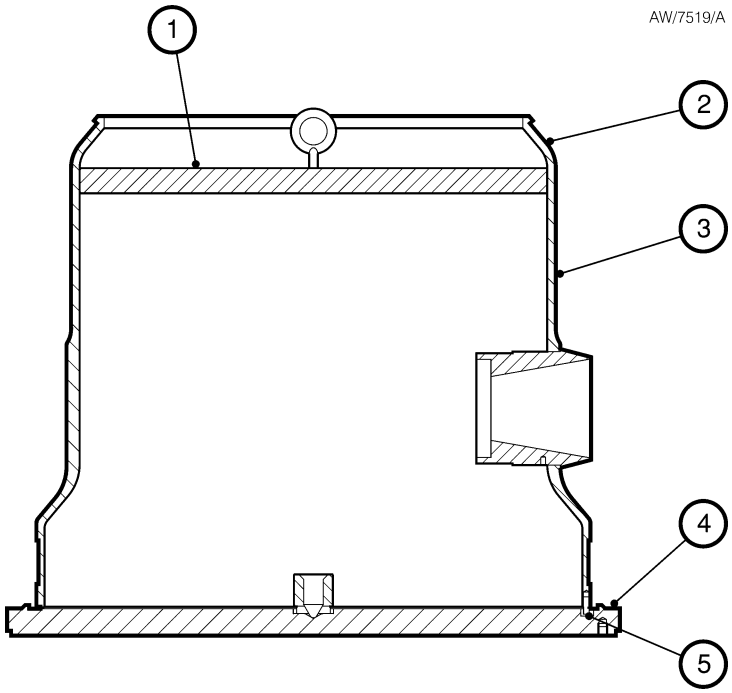
5.6.4 Reassemble the pump

1. Refer to Figure 1. Fit the thermal shields (38, 39), fluid drier assembly (14), the centre tube (15) and the jet-stages (17, 18, 20, 22) to the pump:
   - Centralise each interior jet-stage as you fit it in the pump.
   - When you fit the lower-stage (17), ensure that the outer thermal shield is set correctly on the locating-pin (12). Ensure that the pin engages correctly into the locating slot in the pump base.
   - Ensure that the top-jet assembly is centralised within the pump-inlet.
2. Fit the spring, washer and fixing bolt assembly (23) to the tie-rod (19) and fit the tie-rod in the pump.
3. Fit the top-jet cap (30) and secure with the three fixing screws. Fit the secondary-cap (25).
4. Fit the ceramic spacer (29) to the top-jet cap (30).
5. Ensure that the O-ring (34) is correctly positioned and fit the cool-cap (24) on the pump.
6. Fit the fixing screw, special washer and ceramic washer (26 to 28) to the centre of the cool-cap (24). Tighten the fixing screw (27) to 1.4 Nm.
7. Fit and tighten the cool-cap mounting screws (32).
8. Reconnect your cooling-water supply and return pipelines to the cooling-water inlet (4) and outlet (6).
9. Reconnect the pump to your electrical supply.

Figure 12 - Removal of the lower stage with a lifting bar



1. Lifting bar
2. Rim
3. Lower stage
4. Base flange
5. Locating pin

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5.7 Clean the cooling-coil

The cooling-coil should be cleaned at least once a year, and more regularly if the water supply has a high calcium content.

To clean the cooling-coil, flush with a suitable descaling agent. For example, a 15% hydrochloric acid solution can be used for decalcification, followed by a 5% sodium carbonate solution for neutralization.

5.8 Inspect the heater wires and replace if necessary

WARNING

After you have replaced a heater wire, check the earth (ground) continuity and insulation resistance (refer to Section 4.2) before you reconnect the pump to the electrical supply.

5.8.1 Inspection procedure

Note: *The high temperature wires will normally be discoloured (that is, turn brown) during pump operation. You should only replace the wires if the wires are physically damaged, or if the insulation is detached from the wires.*

You must inspect the heater wires annually; use the following procedure:

1. Isolate the pump from the electrical supply.
2. If there is insufficient room for you to work under the pump:
   - Drain the pump and remove the interior assemblies as described in Sections 5.5 to 5.6.2.
   - Turn the pump over.
3. Remove the six screws which secure the shield to the pump base, then remove the shield from the pump.
4. Inspect all of the wires that connect the heaters to the electrical box terminals. If the insulation or the enclosed conductor of any wire is damaged or cracked, replace the wire: refer to Section 5.8.2.
5. Inspect all of the linking wires that connect the heaters together. If the insulation or the enclosed conductor of any wire is damaged or cracked, replace the wire: refer to Section 5.8.3.
6. Refit the shield to the pump base and secure with the six screws.
7. If necessary (that is, if there was insufficient room for you to work under the pump):
   - Refit the interior assemblies in the pump: refer to Section 5.6.4.
   - Fill the pump with new fluid: refer to Section 3.8.
8. Reconnect the pump to the electrical supply.

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5.8.2 Replace the heater terminal wires

1. Disconnect the wire to be replaced from the appropriate terminal in the electrical box: refer to Section 5.10. (If necessary, use a multimeter or similar device to identify the wire/terminal.)
2. Refer to Figure 14. Remove the wire from the corresponding heater wire clips (3).
3. Carefully ease the wire out of the conduit, and remove the wire from the pump.
4. Route the new wire through the conduit.
5. Connect the ring terminal on the wire to the heater terminal, then fit the wire under the corresponding heater wire clips (3).
6. Cut the wire to the correct length, then connect the end of the wire to the appropriate terminal in the electrical box.

5.8.3 Replace the heater connecting wires

1. Refer to Figure 14. Disconnect the ring terminal on each end of the wire to be replaced from the heater terminal on the appropriate heater.
2. Remove the wire from the corresponding heater wire clips (3).
3. Fit the new wire under the corresponding heater wire clips (3).
4. Connect the ring terminal on each end of the new wire to the heater terminal on the appropriate heater.

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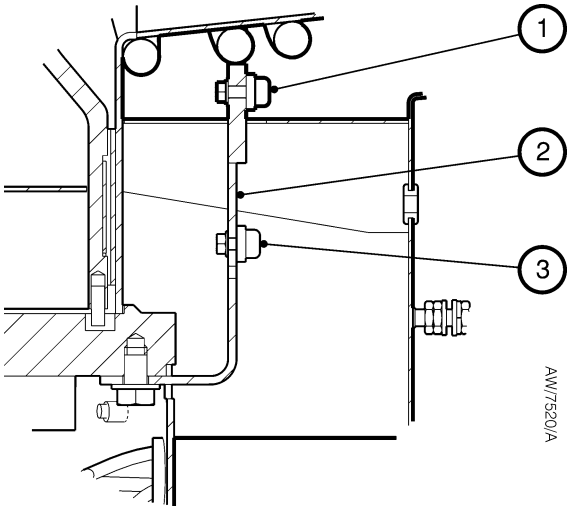
5.9 Replace the thermal snap-switches

Note: *The cooling-coil thermal snap-switch has a longer mounting stud than the pump base (boiler) thermal snap-switch. The cooling-coil thermal snap-switch must be fitted so that it is uppermost on the thermal strap, as shown in Figure 13.*

If you need to replace the thermal snap-switches, check and correct the cause of failure before you operate the pump again. Refer to Figure 13 and use the procedure below to replace the thermal snap-switches.

1. Ensure that the pump has been isolated from the electrical supply and has cooled down.
2. Support the base tray while you undo and remove the six screws which secure the base tray to the electrical box: note that there are three screws on each side of the electrical box (see Figure 1).
3. Lower the base tray sufficiently so that you can access the two wires connected to terminals 1 and 2 in the electrical box (see Figures 7 and 8) and disconnect the cables from the terminals.
4. Remove the grommet from the rear of the electrical box.
5. Remove the thermal snap-switches; use the following method for each snap-switch:
   - Undo and remove the retaining nuts from the thermal snap-switch (1 or 3).
   - Remove the thermal snap-switch from the thermal strap (2).
6. Fit the new thermal snap-switches; use the following method for each snap-switch:
   - Fit the thermal snap-switch (1 or 3) to the thermal strap (2).
   - Fit and tighten the retaining nuts to secure the thermal snap-switch.
7. Refit the grommet to the rear of the electrical box.
8. Connect the two thermal snap-switch wires to terminals 1 and 2 in the electrical box (see Figures 7 and 8).
9. Raise the base tray back into position, then fit and tighten the six screws (three screws on each side) to secure the base tray in the electrical box (see Figure 1).

Figure 13 - Thermal snap-switches



1. Cooling-fail thermal snap-switch
2. Thermal strap
3. Pump base (boiler) thermal snap-switch

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5.10 Replace a heater

5.10.1 Remove the heaters

Use the following procedure to remove the heaters. Refer to Figures 14 and 15.

1. Isolate the pump from the electrical supply.
2. If there is insufficient room for you to work under the pump:
   - Drain the pump and remove the interior assemblies as described in Sections 5.4 to 5.6.
   - Turn the pump over.
3. Remove the six screws which secure the shield to the pump base, then remove the shield from the pump.
4. Undo the heater electrical supply studs and remove the terminals from the heaters.
5. Remove the M16 nut and washer from the centre stud of each heater.
6. Remove the heaters from the base assembly.

5.10.2 Fit the new heaters

WARNING

After you have replaced a heater, check the earth (ground) continuity and insulation resistance (refer to Section 4.2) before you reconnect the pump to the electrical supply.

1. Inspect the base assembly and check that it is flat and undistorted. If it is distorted, contact your supplier or Edwards.
2. Inspect all of the heater wires still fitted to the pump and replace if necessary: refer to Section 5.8.
3. Place the new heaters over the studs with the terminal studs in approximately their final positions.
4. Coat the threads lightly with a heat-resistant anti-seize compound (we recommend the use of Never-Seez ®) and screw the M16 fixing nuts and washers down, finger-tight only.
5. Loosely fit the heater wires to the heater studs, then adjust the orientations of the heaters as necessary, so that the terminal studs are in their final locations.
6. Ensure that there is a minimum gap of at least 12 mm between all of the conductors/heater terminals, and between the conductors/heater terminals and the body of the pump.
7. Tighten the heater fixing nuts:
   - Tighten the nut nearest the heater to a maximum torque of 54 N m (40 lbf ft).
   - Tighten the other nut to a maximum torque of 68 N m (50 lbf ft).
8. Refit the shield to the pump base and secure with the six screws.

5.11 Fault finding

A list of fault conditions and their possible causes is provided in Table 12 (page 48) to assist you in basic fault-finding.

If problems persist, contact your supplier or your nearest Edwards Service Centre.

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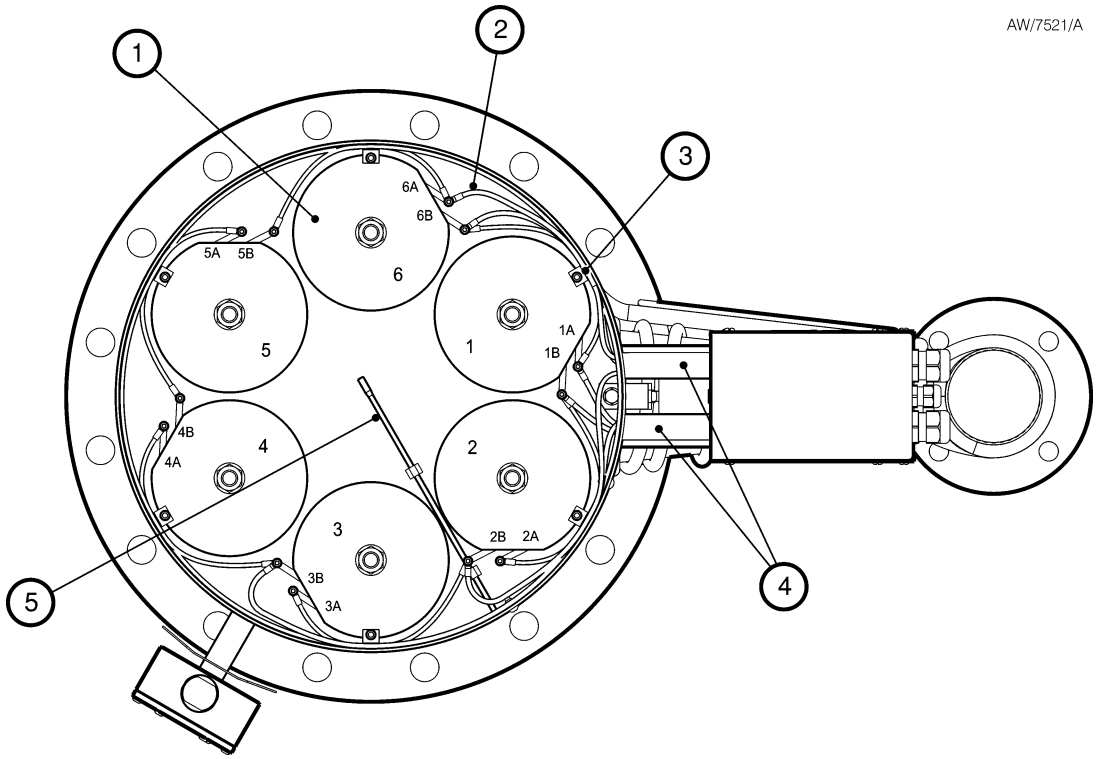
Figure 14 - HT16B pump base and heaters (with outer radiation shield removed)



1. Heater (6 off)
2. Heater link wire
3. Heater wire clips
4. Conduit
5. Thermal probe sleeve

Heater supply (long) wire connections	
Heater terminal	Electrical-box (Figure 7) terminal
1 A	3
1 B	5
2 B	8
3 B	7
6 A	4
6 B	6

Heater link (short) wire connections	
Heater terminal	Heater terminal
1 A	5 B
1 B	3 A
2 B	4 A
3 B	5 A
6 A	4 B
6 B	2 A

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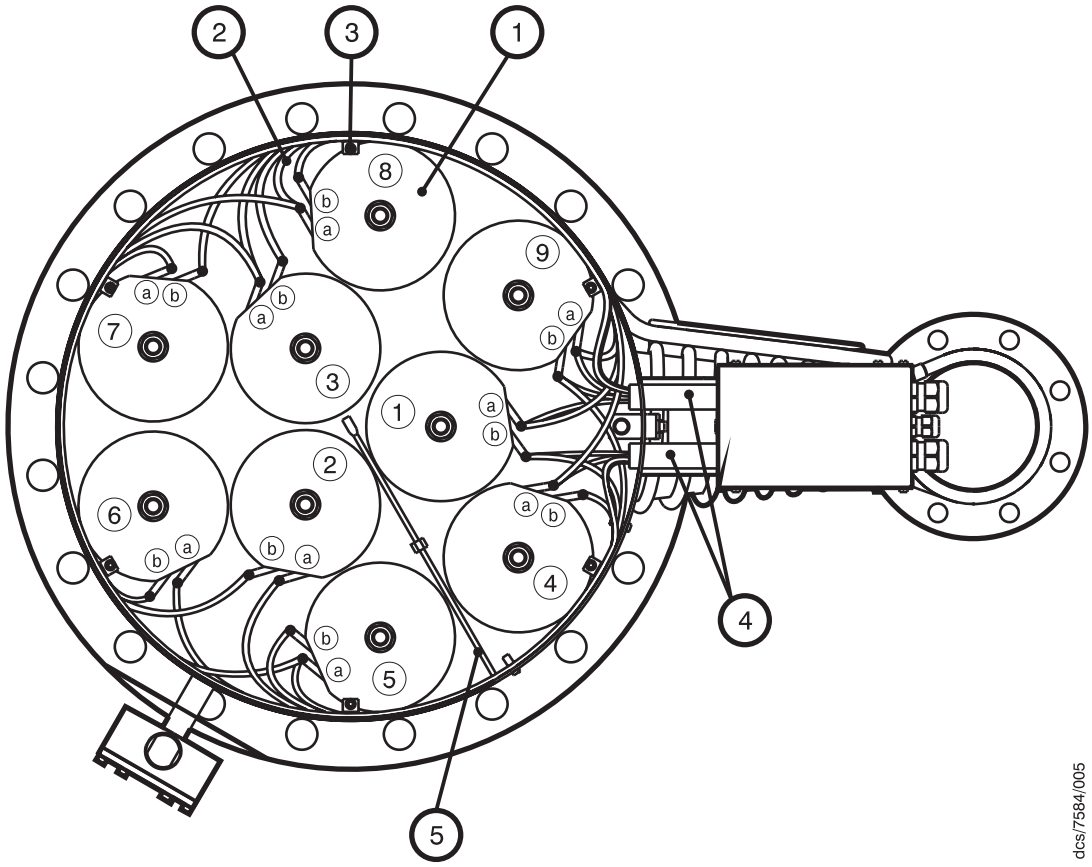
Figure 15 - HT20B pump base and heaters (with outer radiation shield removed)



1. Heater (9 off)
2. Heater link wire
3. Heater wire clips
4. Conduit
5. Thermal probe sleeve

Heater supply wire connections	
1 a	3
1 b	6
3 a	9
4 a	4
4 b	7
5 b	11
8 a	10
9 a	5
9 b	8

Heater link wire connections	
1 a	3 b
3 a	2 b
2 a	1 b
4 a	8 b
8 a	6 b
6 a	4 b
9 a	7 b
7 a	5 b
5 a	9 b

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Table 12 - Fault finding

Symptom	Check	Actions
The pump will not start.	Is the electrical supply disconnected, or is it faulty?	Ensure that the pump is correctly connected to the electrical supply (see Section 3.5), and that the electrical supply is the correct voltage and frequency (see Section 2.6).
	Has the electrical supply overload tripped?	Check the earth (ground) continuity (see Section 4.2.1) and the insulation resistance of the heaters (see Section 4.2.2). If the earth (ground) continuity and insulation resistance are correct, there may be an electrical fault in the pump: contact your supplier or Edwards for advice.
	Has the (optional) backing pressure interlock operated to shut down the pump?	Ensure that the backing pump is suitable for use with the HT and your system (refer to Section 2.1), and that you reduce the backing pressure to the correct pressure before you open the backing valve (assuming that you have a fully valved pumping system: see Section 4.3.1). If you have checked the above and cannot identify a problem, check for a leak into the system or into the pump: refer to the actions for the "The pump fails to reach ultimate vacuum..." symptom on page 49.
	Has the cooling-fail thermal snap-switch operated to shut down the pump ?	Ensure that the cooling-water supply is on and that its temperature and flow rate are correct (refer to Section 2.5), then restart the pump.
The pump shuts down.	Is the electrical supply disconnected?	Ensure that the pump is correctly connected to the electrical supply (see Section 3.5), and that the electrical supply is the correct voltage and frequency (see Section 2.6).
	Has the electrical supply overload tripped?	Check the earth (ground) continuity (see Section 4.2.1) and the insulation resistance of the heaters (see Section 4.2.2). If the earth (ground) continuity and insulation resistance are correct, there may be an electrical fault in the pump: contact your supplier or Edwards for advice.
	Has the cooling-fail thermal snap-switch operated to shut down the pump ?	Ensure that the cooling-water supply is on and that its temperature and flow rate are correct (refer to Section 2.5), then restart the pump.
	Has the boiler protection thermal snap-switch operated to shut down the pump?	Inspect the pump fluid-level (refer to Section 5.4) and add more fluid if necessary.

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Table 12 - Fault finding (continued)

Symptom	Check	Actions
The pump shuts down. (continued)	Has the (optional) backing pressure interlock operated to shut down the pump?	Ensure that the backing pump is suitable for use with the HT and your system (refer to Section 2.1), and that you reduce the backing pressure to the correct pressure before you open the backing valve (assuming that you have a fully valved pumping system: see Section 4.3.1). If you have checked the above and cannot identify a problem, check for a leak into the system or into the pump: refer to the actions for the "The pump fails to reach ultimate vacuum..." symptom below.
The pump fails to reach ultimate vacuum, or low-pressure pumping speed (below 1 x 10^{-3} mbar, 1 x 10^{-1} Pa) is poor.	Is there a leak in your vacuum system?	Leak test your vacuum system and seal any leaks found.
	Is there a leak in the pump?	Leak test the pump with the inlet and outlet flanges sealed. If the pump leaks, contact your supplier or Edwards for advice.
	Is the pump fluid contaminated or has it deteriorated?	Inspect the pump fluid and replace if necessary: refer to Section 5.5.
	Has the pump been filled with the wrong fluid?	Drain the pump fluid and fill the pump with the correct fluid: refer to Section 5.5.
	Is your vacuum system contaminated or dirty?	Inspect the vacuum system and clean/ decontaminate it as necessary
	Has a heater failed?	Inspect the heaters and replace as necessary: refer to Section 5.10.
	Is the cool-cap misaligned?	Dismantle the pump, check the alignment of the cool-cap and correct if necessary, then reassemble the pump: refer to Section 5.6.
	Have you just filled the pump with new fluid?	If you have just filled the pump with new fluid, the fluid may be outgassing. The outgassing rate should stabilise, and the pressure should start to fall, within 1 hour.
	Has the vacuum system been opened to atmosphere?	If the vacuum system has recently been opened to atmosphere, the system components may be outgassing. The pressure will eventually decrease, but this may take many hours.
	Has backing pump oil backstreamed into the HT pump?	Drain and clean the HT pump (see Section 5.6), then fill it with new fluid (see Section 5.5).
	Is the cooling-water supply inadequate, or is it incorrectly connected?	Ensure that the cooling-water supply is on and that its temperature and flow rate are correct (refer to Section 2.5). Ensure that the cooling-water supply and return pipelines are correctly connected to the pump (refer to Section 3.6).
	Is your pressure gauge incorrectly calibrated or contaminated?	Check the gauge and decontaminate and/or recalibrate it as necessary.

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Table 12 - Fault finding (continued)

Symptom	Check	Actions
High-pressure pumping speeds (above 1 x 10^{-3} mbar, 1 x 10^{-1} Pa) are poor.	Is the backing pump too small or is it faulty?	Ensure that the backing pump is suitable for use with the HT and your system (refer to Section 2.1) and that it operates correctly. Replace the pump if necessary.
	Is there a leak in the backing pipeline?	Leak test the pipeline and seal any leaks found.
	Is the fluid level incorrect?	Inspect the pump fluid-level (refer to Section 5.4) and correct if necessary.
	Is the pump outlet restricted?	Inspect the outlet (backing) pipeline and remove any restrictions/obstructions. If the outlet pipeline is not restricted/obstructed, check the outlet flange and baffle assembly for debris/contaminants, and remove if necessary.
	Is the pump interior assembly installed incorrectly?	Dismantle the pump, check the installation of the pump interior and reassemble the pump: refer to Section 5.6.
	Has a pump heater failed?	Inspect the heaters and replace as necessary: refer to Section 5.10.
	Is the backing pipeline configuration incorrect?	Check that the backing pipeline is as short as possible and has the largest possible diameter (as described in Section 3.4.1). Replace the pipeline or reconfigure your vacuum system as necessary.
Pumping speed or pressure is unstable.	Is the fluid return to the pump boiler restricted?	Dismantle and clean the pump, then reassemble the pump: refer to Section 5.6.
	Is the pump fluid-level incorrect?	Inspect the pump fluid-level (refer to Section 5.4) and correct if necessary.
	Is the pump fluid contaminated or has it deteriorated?	Inspect the pump fluid and replace if necessary: refer to Section 5.5.
	Has the pump been filled with the wrong fluid?	Drain the pump fluid and thoroughly clean the pump, then fill the pump with the correct fluid: refer to Section 5.5.
	Is your vacuum system contaminated or dirty?	Inspect the vacuum system and clean/ decontaminate it as necessary
	Is the cool-cap misaligned?	Dismantle the pump, check the alignment of the cool-cap and correct if necessary, then reassemble the pump: refer to Section 5.6.
	Is the cooling-water supply incorrect or is the water flow through the pump restricted?	Ensure that the cooling-water supply is on and that its temperature and flow rate are correct (refer to Section 2.5). If the cooling-water supply is correct, clean the cooling-coils (refer to Section 5.7).
	Is the pump interior assembly installed incorrectly?	Dismantle the pump, check the installation of the pump interior and reassemble the pump: refer to Section 5.6.
	Has backing pump oil backstreamed into the HT pump?	Drain and clean the HT pump (see Section 5.6), then fill it with new fluid (see Section 5.5).

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Table 12 - Fault finding (continued)

Symptom	Check	Actions
Pumping speed or pressure is unstable. (continued)	Is there a leak in your vacuum system ahead of the HT inlet?	Leak test your vacuum system and seal any leaks found.
	Is heater power incorrect?	Inspect the heaters and replace as necessary: refer to Section 5.10. If the heaters are correct, check that your electrical supply is the correct voltage and frequency (see Section 2.6).
	Have you just filled the pump with new fluid?	If you have just filled the pump with new fluid, the fluid may be outgassing. The outgassing rate should stabilise, and the pressure should start to fall, within 1 hour.
	Has the vacuum system been opened to atmosphere?	If the vacuum system has recently been opened to atmosphere, the system components may be outgassing. The pressure will eventually decrease, but this may take many hours.
Backstreaming is excessive.	Is the cool-cap misaligned, or is the secondary cool-cap missing?	Dismantle the pump, check the alignment of the cool-cap and correct if necessary, check that the secondary cool-cap is fitted, then reassemble the pump: refer to Section 5.6.
	Is the cooling-water supply incorrect or is the water flow through the pump restricted?	Ensure that the cooling-water supply is on and that its temperature and flow rate are correct (refer to Section 2.5). If the cooling-water supply is correct, clean the cooling-coils (refer to Section 5.7).
	Is the pump interior assembly installed incorrectly?	Dismantle the pump, check the installation of the pump interior and reassemble the pump: refer to Section 5.6.
	Has fine pumping been started too early, or is the backing pressure too high?	Ensure that the backing pump is suitable for use with the HT and your system (refer to Section 2.1), and ensure that the chamber pressure is sufficiently low before you open the high-vacuum isolation valve (see Section 4.3).
Pump fluid loss is excessive.	Is the pump-outlet condenser backing baffle missing ?	Dismantle the pump, check that the backing-baffle is correctly fitted, then reassemble the pump: refer to Section 5.6.
	Is the cooling-water supply incorrect or is the water flow through the pump restricted?	Ensure that the cooling-water supply is on and that its temperature and flow rate are correct (refer to Section 2.5). If the cooling-water supply is correct, clean the cooling-coils (refer to Section 5.7).
	Has the pump stalled?	If possible, reduce the gas load. Also, check for a leak into the system or into the pump: refer to the actions for the "The pump fails to reach ultimate vacuum..." symptom on page 49.
	Has the pump been operated with high throughput for an extended period?	If possible, reduce the throughput, or reduce the time spent fine pumping.

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Table 12 - Fault finding (continued)

Symptom	Check	Actions
Pump fluid loss is excessive. (continued)	Is there a leak into the pump boiler?	Inspect the oil drain-plug, oil-filler plug and fluid-level sight-glass O-rings (see Figure 1) and replace if necessary.
	Does your system incorporate a liquid nitrogen trap immediately above the HT pump?	Move the trap so that it is further away from the HT inlet.
	Has fine pumping been started too early, or is the backing pressure too high?	Ensure that the backing pump is suitable for use with the HT and your system (refer to Section 2.1), and ensure that the chamber pressure is sufficiently low before you open the high-vacuum isolation valve (see Section 4.3).
-	-	If you cannot rectify a fault, or if you cannot identify the cause of a fault, contact your supplier or Edwards for advice.

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6 Storage and disposal

6.1 Storage

Use the procedure below to store the HT pump:

1. Shut down the pump as described in Section 4.5.
2. Isolate the pump from the electrical supply, disconnect it from your vacuum system and drain the pump fluid as described in Section 5.5.
3. Clean the pump as described in Section 5.6.
4. Reassemble the pump as described in Section 5.6. Do not refill the pump with fluid.
5. Place protective covers over the inlet and outlet-flanges and the cooling-water supply and return connectors.
6. Store the pump in cool dry conditions until it is required for use. When required, prepare and install the pump as described in Section 3.

6.2 Disposal

Dispose of the HT pump and any components removed from it safely in accordance with all local and national safety and environmental requirements.

Take particular care with the following:

- Components which have come into contact with pump fluid
- Fluoroelastomers which may have been subjected to temperatures above 260 °C (see Section 5.1)
- Breakdown products which may be present if the pump fluid has been subjected to temperatures above the fluid breakdown temperature.
- Components which have been contaminated with dangerous process substances.

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7 Service, spares and accessories

7.1 Introduction

Edwards products, spares and accessories are available worldwide from Edwards companies and our network of distributors. Please refer to the back page of this manual or to www.edwardsvacuum.com for contact information.

Order spare parts and accessories from your nearest Edwards company or distributor. When you order, please state for each part required:

- Model and Item Number of your equipment.
- Serial number (if any).
- Item Number and description of the part.

7.2 Service

Edwards products are supported by a worldwide network of Edwards Service Centres. Each Service Centre offers a wide range of options including: equipment decontamination; service exchange; repair; rebuild and testing to factory specifications. Equipment which has been serviced, repaired or rebuilt is returned with a full warranty.

Your local Service Centre can also provide Edwards engineers to support on-site maintenance, service or repair of your equipment.

For more information about service options, contact your nearest Service Centre or other Edwards company.

7.3 Spares

The spares for the HT pumps are listed in Table 13 (page 56).

7.4 Accessories

The accessories available for the HT pump are described in the following sections. Refer to Table 14 (page 56) for the Item Numbers of these accessories.

7.4.1 Thermal probe

Note: *The temperatures specified in this manual were measured at the edge of the base flange of the HT pump (Figure 1, item 11). The thermal probe does not sense the temperature at the same point of the pump. The temperatures and curves in this manual are therefore different from those specified for the Thermal Probe accessory in the HT Diffusion Pump Accessories instruction manual.*

The Thermal Probe senses changes in temperature at the base flange of the pump. The electrical output of the probe can be used (with a suitable panel meter or warning device) to indicate when the fluid-level is low or when the pump-heater has failed.

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7.4.2 Inlet baffle

The inlet baffle reduces backstreaming of pump fluid (to less than 5 x 10^{-5} mg cm^{-2} min^{-1}) with only a small loss of pump performance.

Table 13 - HT pump spares

Spare	Item Numbers	
	HT16B	HT20B
DC704EU pump fluid (500 ml)	H112-01-040	H112-01-040
Thermal snap-switch assembly	B311-01-090	B311-01-090
Heater wire pack (complete set)	B312-20-085	B314-20-085
Heater link wire *	B312-20-086	B314-20-086
Heater connection wire *	B312-20-087	B314-20-087
Drain/filler assembly O-ring (fluoroelastomer): pack of 5	H021-06-022	H021-06-022
ANSI16 inlet-port O-ring (nitrile)	H021-24-149	-
ANSI20 inlet-port O-ring (nitrile)	-	H021-24-151
ANSI3 outlet-port O-ring (nitrile): pack of 2	H021-05-059	-
ANSI4 outlet-port O-ring (Viton™): pack of 2	-	H021-05-075
ISO600 inlet-port trapped O-ring (neoprene)	B312-05-081	-
ISO630 inlet-port trapped O-ring (neoprene)	-	B314-02-081
ISO100 outlet port Co-Seal (nitrile)	B271-58-177	-
ISO160 outlet port Co-Seal (nitrile)	-	B271-58-178
Cool-cap O-ring: pack of 2	H021-06-159	H021-06-159
Fluid level sight-glass O-ring (fluoroelastomer) and gasket (Gore-tex®)	B312-20-088	B312-20-088
Fluid heater	(1500W)	(1400W)
200 V	H017-06-020	H017-06-113
220 V	H017-06-021	H017-06-114
380 V	H017-06-022	H017-06-115
400 V	H017-06-023	H017-06-116
415 V	H017-06-024	H017-06-117
440 V	H017-06-028	H017-06-118
460 V	H017-06-025	H017-06-119
480 V	H017-06-026	H017-06-120

* *A pack of 6 is supplied for the HT16B pump and a pack of 9 is supplied for the HT20B pump.*

Table 14 - HT pump accessories

Accessory	Item Numbers	
	HT16B	HT20B
Thermal Probe	B612-21-000	B614-21-000
Inlet baffle	B612-03-000	B614-03-000

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