B344-50-880
Issue B

Instruction Manual

SI100 Diffusion Pump

Description	*Item Number*
SI100 Diffusion Pump, 90 V a.c. pump heater electrical supply	*B344-50-090*
SI100 Diffusion Pump, 180 V a.c. pump heater electrical supply	*B344-50-180*

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Declaration of Conformity

We, *BOC Edwards,*
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declare under our sole responsibility that the product(s)

SI100 Vapour Diffusion Pump (90 V)	*B344-50-090*
SI100 Vapour Diffusion Pump (180 V)	*B344-50-180*

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

IEC1010-1 (1992)	*Safety requirements for electrical equipment for measurement, Control and laboratory use.*
EN61000-3-2	*Electromagnetic compatibility - Limits for harmonic Current emissions.*
EN61000-3-3	*Electromagnetic compatibility - Limitation of voltage Fluctuations and flicker in low voltage supply systems.*
PrEN1012-2 (1993)	*Compressors and vacuum pumps - Safety requirememnts: Vacuum pumps.*

following the provisions of

73/023/EEC	*Low Voltage Directive.*
89/336/EEC	*Electromagnetic Compatibility Directive.*

JDWatson

Dr J. D. Watson, Senior Technical Manager
Vacuum Equipment and Exhaust Management Product Divisions

22/5/01 EASTBOURNE

Date and Place

This product has been manufactured under a quality system registered to ISO9001

BOC EDWARDS

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DBW 5968-99

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Associated publications

Title	Publication Number
Vacuum pump and vacuum system safety	P300-20-000

1 INTRODUCTION

1.1 Scope and definitions

This manual provides installation, operation and maintenance instructions for the BOC Edwards SI100 Diffusion Pump. You must use the pump as specified in this manual.

Read this manual before you install and operate your 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 units used throughout this manual conform to the SI international system of units of measurement.

1.2 Description

The SI100 pump (see Figure 1) is an air-cooled, compact, fast warm-up diffusion pump with an integral baffle. The pump has been designed for high vacuum performance with low backstreaming for use in scientific instruments. In the following description the numbers in brackets refer to the component parts of the pump shown in Figure 2.

The pump body (11) has fins and is air-cooled. Cooling air is blown over the fins by the cooling-fan (4) on the pump. The pump body has a backing condenser (6). The inlet-baffle (20) is thermoelectrically cooled.

The interior of the pump has upper (14) and lower (12) jet-stages, an ejector-stage (7) and a top-jet cap (16). A transit spring (19) is fitted between the interior assembly and the inlet-baffle. This spring prevents damage to the jet-stages and the inlet-baffle when you move the pump.

The pump heater (9) is inside the base of the pump; it heats the pump fluid to generate the required vapour. The radiation shield (8) reduces heat loss from the base of the pump and increases the efficiency of the pump.

The pump has electrical supply cables for the heater, cooling-fan and baffle.

1.3 Principle of operation

Pump fluid is heated in the base of the pump to produce a vapour which passes up through the interior of the jet assembly and emerges from the jets as high-velocity vapour streams. The vapour streams condense on the cooled pump-body wall and drain into the base of the pump for recirculation.

A portion of system gas which arrives at the pump inlet is trapped in the vapour stream from the top jet. The gases are compressed and transferred to the next stage. The gases are then removed by the backing pump through the backing condenser.

The thermoelectrically cooled inlet-baffle has a Peltier-type thermoelectric heat pump; one side cools the internal baffle assembly and the other side is cooled through the housing of the external cooling-fan.

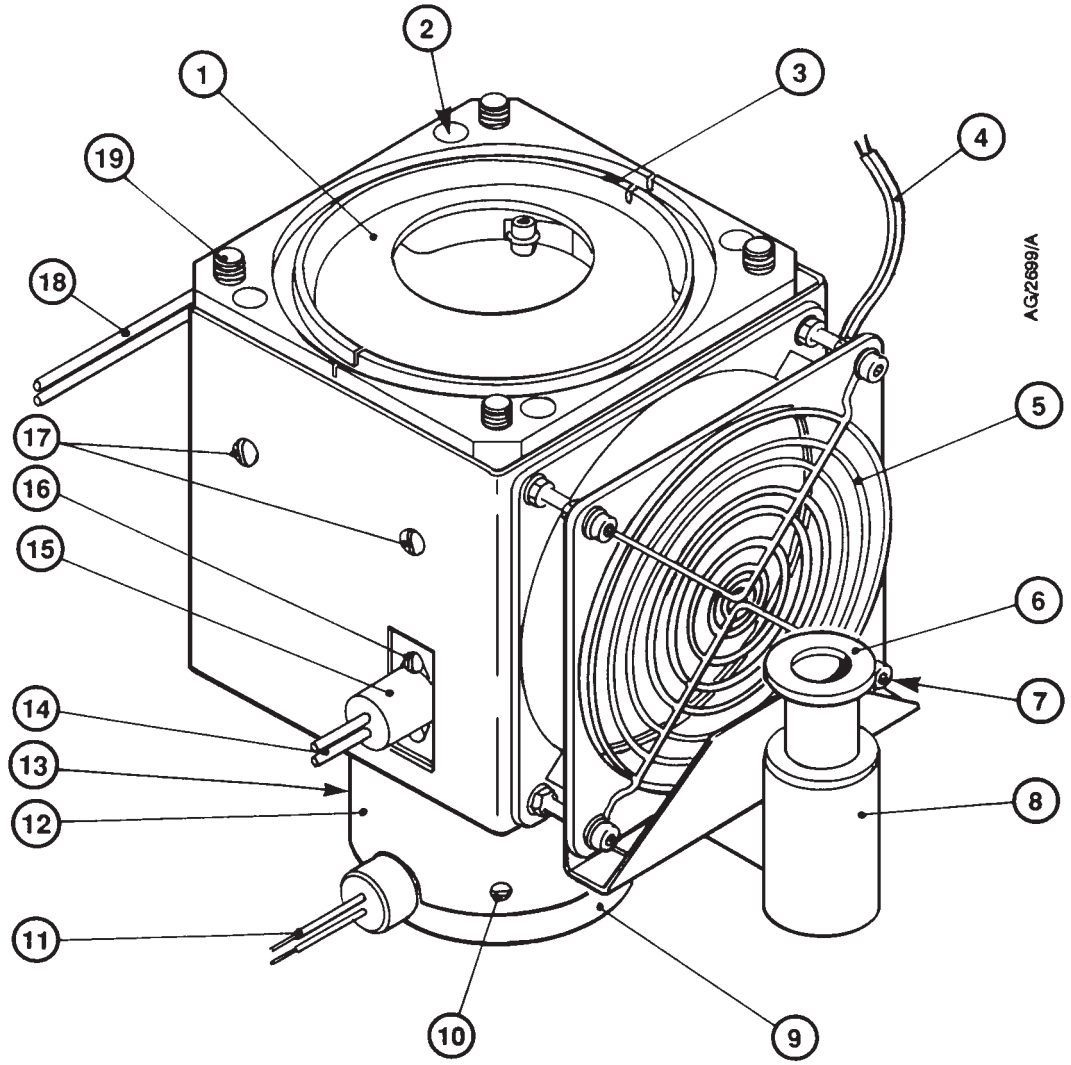
1.4 Operation with high ambient humidity

When the pump is switched off, the heater in the pump will absorb moisture: this will cause a decrease in the insulation resistance of the heater. If you operate the pump in an environment with high ambient humidity, this may cause the heater to fail. The rate of moisture absorption (and therefore the time taken for the insulation resistance of the heater 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.

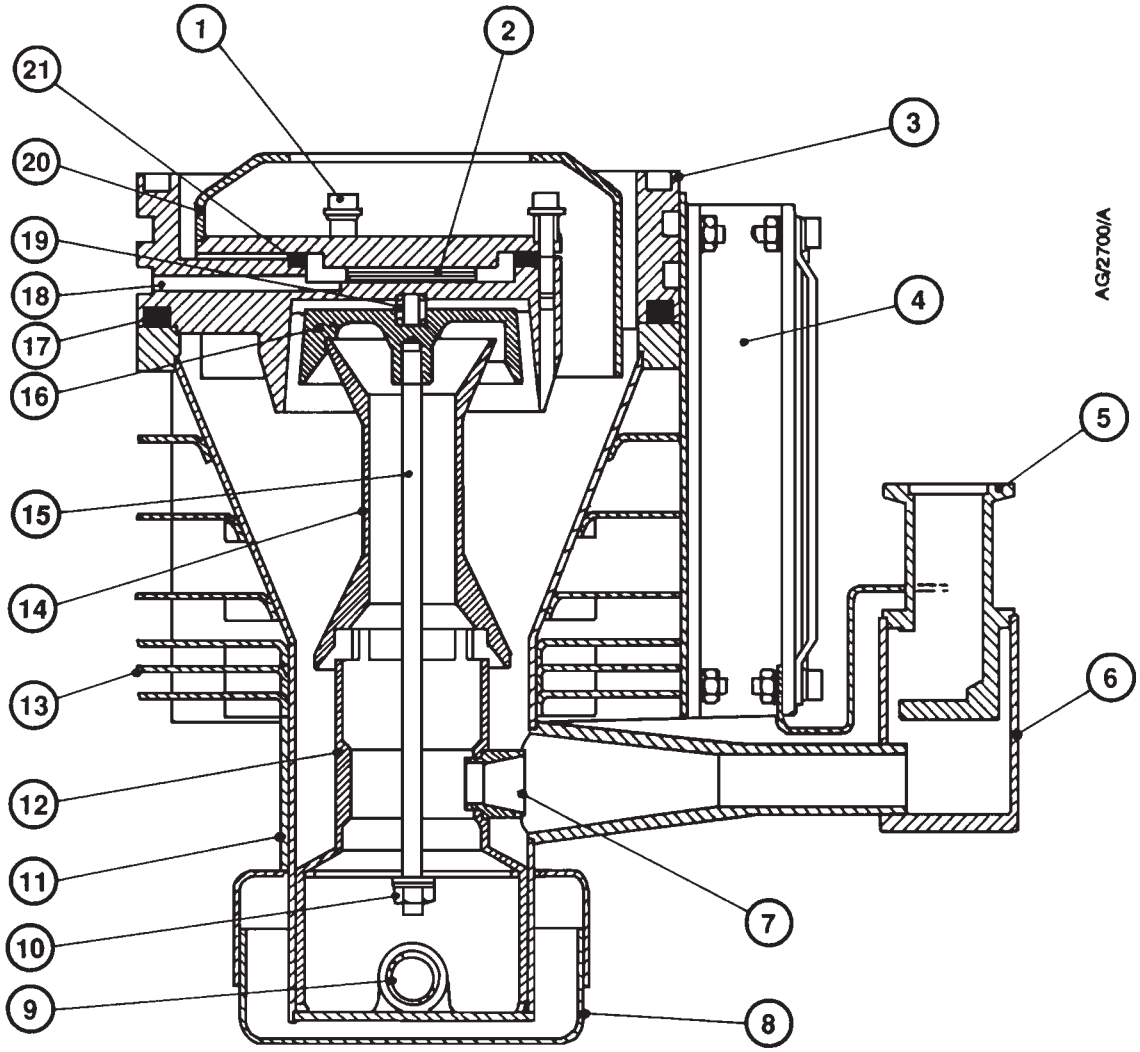
Detailed information about these features are outside the scope of this manual. If you need more information about the operation of the pump with high ambient humidity, request a copy of our Application Note P400-50-000 from your supplier or BOC Edwards.



1. Inlet-baffle
2. Fixing screw (in recess, 4 off)
3. Inlet flange
4. Cooling-fan electrical supply cable
5. Cooling-fan
6. Backing flange
7. Cooling-fan electrical supply socket
8. Backing condenser
9. Radiation shield
10. Fixing screw
11. Heater electrical supply cable
12. Pump base
13. Pump ready thermal snap-switch plate
14. Cooling-fail thermal snap-switch cable *
15. Cooling-fail thermal snap-switch *
16. Fixing screw *
17. Fixing screw
18. Inlet-baffle electrical supply cable
19. Inlet-flange fixing screw

* A cooling-fail thermal snap-switch is not supplied, but is available as an accessory: refer to Section 7.4.

Figure 1 - Components of the SI100 pump



1. Screw (3 off)
2. Thermoelectric device
3. Inlet-flange
4. Cooling-fan
5. Backing flange
6. Backing condenser
7. Ejector-stage
8. Radiation shield
9. Heater
10. Nut and washer
11. Pump body
12. Lower jet-stage
13. Cooling-fins
14. Upper jet-stage
15. Tie-rod
16. Top-jet cap
17. Pump body ‘O’ ring
18. Thermoelectric device cable leadthrough
19. Transit spring
20. Inlet-baffle assembly
21. Inlet-baffle ‘O’ ring

Figure 2 - Cross-section view of the SI100 pump

2 TECHNICAL DATA

2.1 General

Recommended fluid type	Santovac 5
Fluid charge	20 ml
Minimum backing pump displacement for maximum throughput	5 m^3h^{-1}
Recommended backing pumps	See Table 1
Inlet flange	ISO 100 compatible
Backing flange	NW16
Mass	4.2 kg

2.2 Performance data

Pumping speed	
helium	100 ls^{-1}
nitrogen	65 ls^{-1}
air	60 ls^{-1}
Throughput	See Table 1
Backstreaming	1.5 x 10^{-5} $mg.cm^{-2}min^{-1}$
Average fluid loss (steady state)	0.05 $g.hour^{-1}$ $(mbar.ls^{-1})^{-1}$, 5 $(Pa.ls^{-1})^{-1}$
Compression ratio (log_{10})	4.80 at 0.2 mbar (20 Pa) backing pressure
Inlet pressure stability	± 3% at <4 x 10^{-4} mbar gauge (4 x 10^{-2} Pa) over 1 minute (mean pressure variation < 2%)
Maximum ambient operating temperature	35 ^oC
Warm up time	10 minutes
Cool down time	< 20 minutes

Throughput	**Backing pump**				
	RV3	**RV5**	**RV12**	**E2M2**	**E2M12**
$mbar.ls^{-1}$	0.15	0.27	0.27	0.15	0.27
$Pa.ls^{-1}$	15	27	27	15	27

Table 1 - SI100 pump throughput at 4 x 10^{-3} mbar (0.4 Pa)

2.3 Electrical data

Note: You must install a power management system which ensures that the heater input power is between 220 W and 240 W.

Nominal electrical supply	
Pump heater	90 / 180 V a.c.
Cooling-fan	110 / 220 V a.c.
Inlet-baffle	8 to 12 V d.c. (current limited at 1.5 A)
Electrical power consumption	
Pump heater (See Note above)	230 W
Cooling-fan	18 W
Inlet-baffle	12 W
Total	260 W

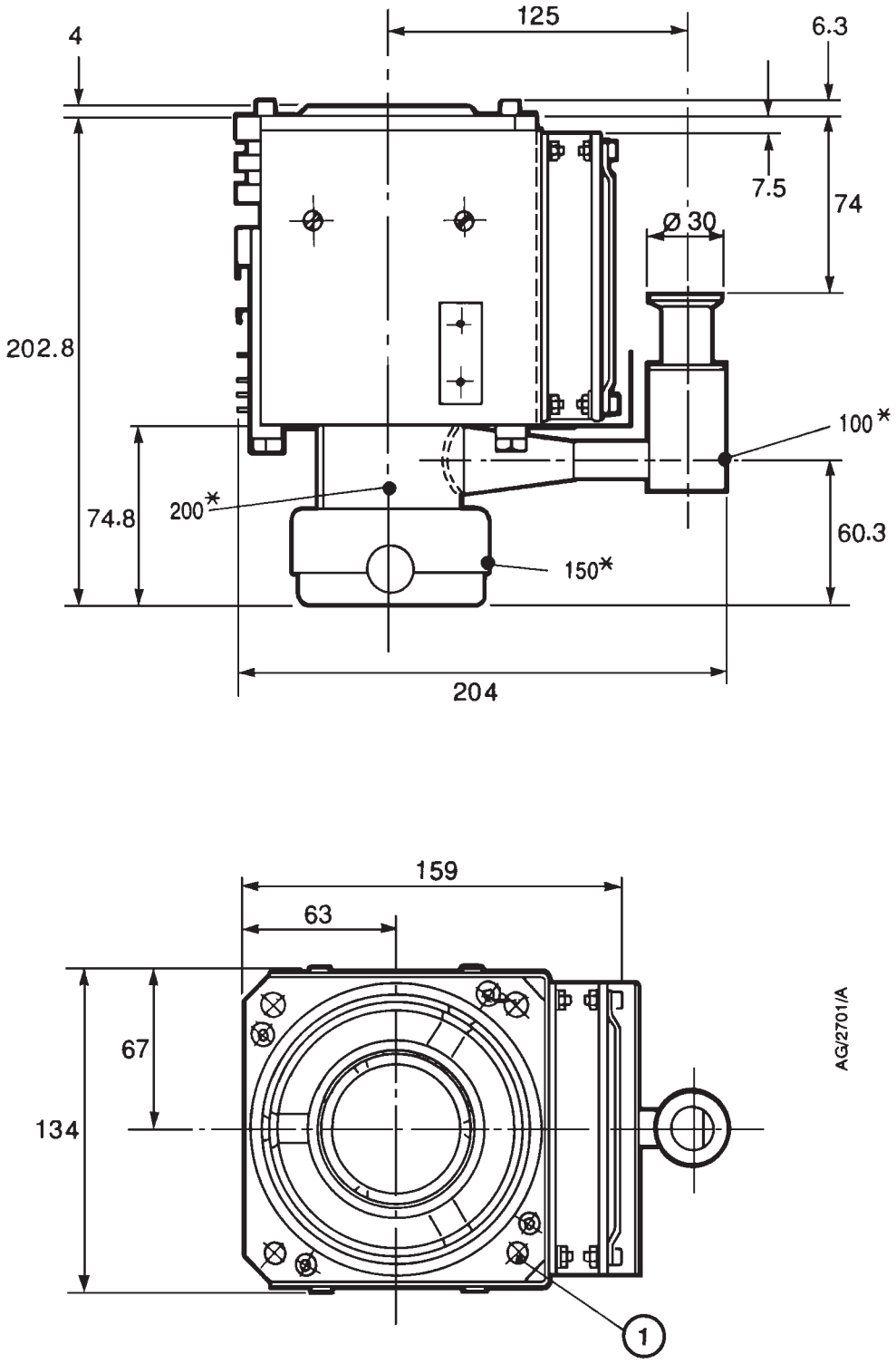
2.4 Pump fluid data

Note: A BOC Edwards Material Safety Data Sheet for Santovac 5 is available on request.

Santovac 5	
Flash point	288 ^{o}C
Auto-ignition point	590 ^{o}C
Molecular weight	446

2.5 Materials of construction

Pump-body	Stainless steel / 3CR12
Interior	Mild steel (nickel plated) and aluminium
Inlet-baffle assembly	Copper (nickel plated) and aluminium
'O' rings	Fluoroelastomer



* Normal operating temperature (^{o}C) at location shown

Figure 3 - Dimensions (mm) and normal operating temperatures

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 SI100 pump.
- Isolate the other components in the vacuum system from the electrical supply before you start work.
- Ensure that the installation technician is familiar with the safety precautions which relate to the materials processed by the vacuum system and those within the vacuum system.
- Consult BOC Edwards publication P300-20-000 (Vacuum pump and vacuum system safety) before you install and use the pump to process hazardous materials.
- Do not use solvents to clean 'O' rings.

3.2 Unpack and inspect

Carefully remove all packing materials and protective covers and check the SI100 Diffusion Pump. Note that the pump has a high centre of gravity: the pump may fall over if you do not support it. 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.

Check that your package contains the items listed in Table 2 below. If any of these items is missing, notify your supplier in writing within three days.

If the SI100 diffusion pump is not to be used immediately, replace the protective covers. Store the pump in suitable conditions, as described in Section 6.

Qty	Description	Check (✓)
1	SI100 Diffusion Pump	❑
4	Inlet-flange fixing screws	❑
1	Inlet-flange 'O' ring	❑
1	Cooling-fan electrical supply cable (with plug fitted)	❑

Table 2 - Checklist of components

3.3 Locate the pump

> WARNING
>
> 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.

You must operate the pump with the inlet-flange horizontal and at the top. If the pump will be free-standing, you must support the backing pipeline to stabilise the pump. Locate the pump at a practical distance from the electrical supplies.

During operation, surfaces of the pump will be hot; Figure 3 shows the temperature of the surfaces of the pump when it is at operating temperature. You must install the pump in an enclosure to protect people from the hot surfaces. Table 3 shows the minimum distance required between the pump components identified in Figure 2 and the enclosure.

Pump component	**Minimum distance between pump component and enclosure**
Backing condenser (Figure 2, item 6)	5 mm
Radiation shield (Figure 2, item 8)	10 mm

Table 3 - Minimum distance required between the pump components and the enclosure

3.4 Inlet connection

The pump has an ISO 100 compatible inlet-flange with an ‘O’ ring groove. Connect the inlet of the pump to your vacuum system as described below. Ensure that the connection between the pump and your vacuum system is as short as possible and has the maximum possible internal diameter.

1. Ensure that the inlet-flange and vacuum system sealing faces are clean and scratch-free; refinish the sealing faces if necessary.
2. Inspect and clean thoroughly the inlet-flange ‘O’ ring and the ‘O’ ring groove on the inlet-flange.
3. Refer to Figure 1. Apply a light wipe of pump fluid or vacuum grease to the inlet-flange ‘O’ ring, then fit the inlet-flange ‘O’ ring into the ‘O’ ring groove (3).
4. Use the four fixing screws supplied (19) to connect the pump to your vacuum system.

3.5 Backing connection

WARNING

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

WARNING

If you will pump dangerous substances, you must fit a backing pressure-interlock.

Ensure that the connecting pipeline to the backing pump is as short as possible and has the maximum possible internal diameter.

You must use the correct type of exhaust extraction system for your process. The extraction system must be designed to withstand the pressures of operation and, when hazardous materials are produced or processed, must be sufficiently leaktight to contain the process materials and their by-products.

On all applications, we recommend that you fit a backing pressure-interlock to the backing 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 pump dangerous substances. If you do not fit a pressure-interlock and the pressure in the backing 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.

Use the following procedure to connect the backing-flange to the backing pipeline.

1. Ensure that the backing-flange and the backing pipeline sealing faces are clean and scratch-free; refinish the sealing faces if necessary.
2. Apply a light wipe of pump fluid or vacuum grease to a suitable NW16 Co-Seal (which you must supply).
3. Use the Co-Seal and an NW clamping ring (which you must supply) to connect the backing-flange to the backing pipeline.

3.6 Fit the thermal snap-switch accessories (optional)

If required, fit a cooling-fail thermal snap-switch and / or a pump ready thermal snap-switch to the pump, and connect each snap-switch as described in the instruction manual supplied with each snap-switch.

Note: Figure 1 shows a cooling-fail thermal snap-switch accessory fitted to the pump, and Section 3.7 provides guidance on its connection.

3.7 Pump electrical connections

> WARNING
>
> Ensure that the electrical installation of the SI100 Diffusion Pump conforms with your local and national safety requirements. The pump must be connected to a suitable fused and protected electrical supply and a suitable earth (ground) point.

Connect the pump heater, cooling-fan and inlet-baffle to the electrical supplies as described below.

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

For additional electrical safety:

- If you do not use conduit for the heater electrical supply cable, use cable which is heat-resistant (up to 150 ^{o}C) in case of accidental contact with the pump
- Provide suitable strain-relief restraints for all of the cables.
- Fit an emergency stop button, an electrical supply isolator and an over-current trip. Set the over-current trip in accordance with the recommendations given in Section 2.3.
- Check the earth (ground) continuity of the pump electrical supply before you switch on the pump.

1. Check that your electrical supply voltage corresponds with the pump rating plate. Note that the heater, cooling-fan and inlet-baffle all use different supply ratings, as specified on the pump rating plate.
2. Refer to Figure 1. Connect one of the earth (ground) screw connections on the cooling-fail thermal snap-switch plate (13) to a suitable earth (ground) point.
3. Connect the heater to your electrical supply with the cable provided (11).
4. If you have fitted a cooling-fail thermal snap-switch accessory, use the cable provided (14) to connect the cooling-fail thermal snap-switch in series with the heater electrical supply, or in series with an appropriate protective circuit.
5. Fit the plug on the end of the cooling-fan electrical supply cable (4) into the socket (7) on the cooling-fan. Connect the other end of the cable provided (4) to your electrical supply; note that it does not matter which way round you connect the wires.
6. Connect the inlet-baffle to your electrical supply with the cable provided (18):
    - Connect the red wire to the positive supply.
    - Connect the black wire to the negative supply.

3.8 Leak test the pump

The SI100 pump is stringently leak tested before dispatch. After you install the pump, leak test the system before you fill the pump with fluid, and seal any leaks found. Outgassing from the fluid may give false test results. The pump fluid is viscous at ambient temperature and may block small leaks.

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

3.9 Fill the pump with fluid

3.9.1 Safety of vapour pump fluid

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 4 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.

3.9.2 Recommended pump fluid

This pump is designed to operate with Santovac 5 fluid. If you use a different fluid, the performance of the pump may be reduced.

The thermal breakdown products of some fluids can be dangerous; details of the breakdown products are given in Table 4. The pump has a protection system which prevents the pump from getting to temperatures at which this thermal breakdown occurs.

3.9.3 Filling procedure

1. Pour the required amount of fluid (see Section 2.1) into a clean container.
2. Disconnect the pump at the backing flange and use a funnel to pour the measured quantity of fluid into the pump through the backing condenser.

   Alternatively, if the pump is not connected to the vacuum system, you can pour the fluid through the inlet flange.
3. Allow the fluid to drain into the pump for five minutes.
4. Reconnect the backing flange to the vacuum system.

Vapour pump fluid	BOC Edwards Product	Auto-ignition Temp. ^{o}C	Break-down Temp. ^{o}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	BOC Edwards L9	370	≈ 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	≈ 460 (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

Table 4 - Vapour pump fluid thermal breakdown

4 OPERATION

4.1 Introduction

WARNING

Do not touch any part of the SI100 pump when it is switched on. Surfaces of the pump are very hot and can cause injury to people and damage to equipment.

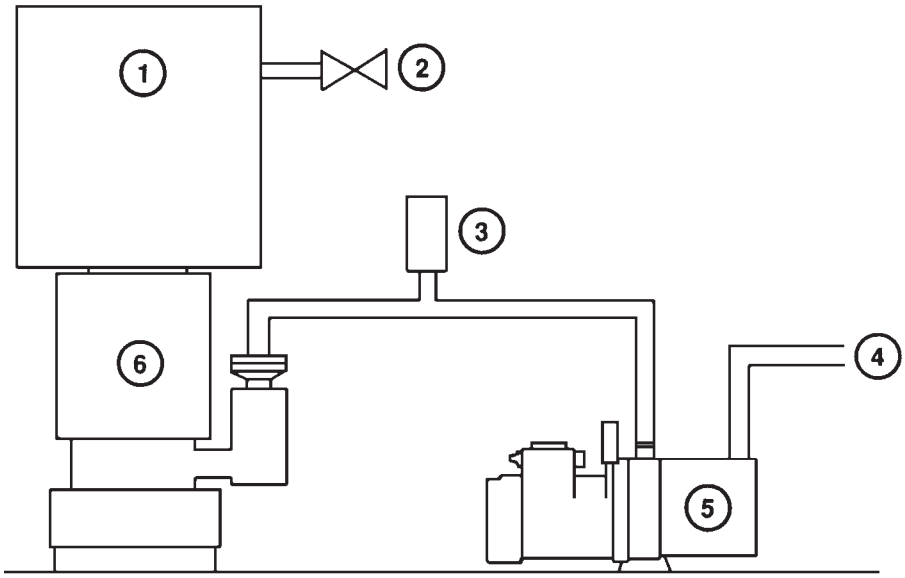
The following sections assume that the SI100 pump will be used in conjunction with a pumping system as shown in Figure 4. Item numbers in brackets in the following sections refer to the components of the pumping system in Figure 4.

4.2 Check the insulation resistance of the heater

If the pump heater has absorbed moisture while the pump was switched off, the insulation resistance of the heater may be too low. Use the following procedure to measure the insulation resistance of the heater 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 heater 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 this procedure to check the insulation resistance of the heater before you reset the RCCB.

1. Measure the insulation resistance (at 500 V d.c.) between the heater terminals and earth (ground).
   - If the insulation resistance is greater than 1 MΩ, you can switch on the pump.
   - If the insulation resistance is less than 1 MΩ, continue at Step 2 below.
2. Remove the heater from the pump (refer to Section 5.7). Bake the heater in an oven at a temperature of 120 ^{o}C for 12 hours or more.
3. Remove the heater from the oven. Measure the insulation resistance of the heater:
   - If the heater has an insulation resistance greater than 1 MΩ, you can refit the heater to the pump.
   - If the heater has an insulation resistance less than 1 MΩ, repeat Steps 2 and 3 of this procedure. If the insulation resistance of the 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.



1. Vacuum system
2. Air-admittance valve
3. Backing pressure monitor
4. Rotary pump outlet
5. Rotary backing pump
6. SI100 pump

Figure 4 - Typical pumping system

4.3 Pump start-up

We recommend that you use the following procedure when the pump and your vacuum system are at atmospheric pressure.

1. Close the vacuum system air-admittance valve (2) and any other openings to atmospheric pressure.
2. Switch on the backing pump (5); ensure that the SI100 cooling-fan also switches on.
3. When the backing pressure reaches 0.1 mbar (10 Pa) or lower, switch on the electrical supply to the SI100 heater and inlet-baffle. Initially, the backing pressure will increase due to the outgassing of the pump fluid.
4. Allow the pump to warm up for approximately 10 minutes so that it reaches its operating temperature.

4.4 Readmission of air to your vacuum system

1. Switch off the electrical supply to the SI100 pump heater and allow the pump to cool for approximately 20 minutes.
2. Switch off the electrical supplies to the cooling-fan and the inlet-baffle and switch off the backing pump (5).
3. Open the vacuum system air-admittance valve (2).

4.5 Re-evacuation of your vacuum system

Use the procedure in Section 4.3 to re-evacuate your vacuum system.

4.6 Shut-down

As described in Section 1.4, when the pump is switched off, the heater in the pump will absorb moisture: this will cause a decrease in the insulation resistance of the heater. 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 40 ^{o}C above the ambient temperature. 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 BOC Edwards.

1. Switch off the electrical supply to the SI100 pump-heater and allow the pump to cool for approximately 20 minutes.
2. Switch off the electrical supplies to the cooling-fan and the inlet-baffle and switch off the backing pump (5).

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 SI100 pump.
- Ensure that the maintenance technician is familiar with the safety precautions which relate to the materials processed by the vacuum system and to the pump fluid. Wear the appropriate safety clothing when you come into contact with contaminated components. Dismantle and clean contaminated components inside a fume cupboard.
- Isolate the pump from the electrical supply and your vacuum system before you start work.
- Allow the pump to cool for at least 20 minutes before you touch any part of the pump or attempt to move it.
- Do not open the pump to atmospheric pressure until it is cool.
- Do not use abrasive or reactive chemical substances to clean the pump. Do not use solvents to clean Co-Seals, centring rings or 'O' rings.
- The Co-Seals, centring rings and 'O' rings used in this pump are made from a fluoroelastomer. Fluoroelastomers can decompose into very dangerous substances if they are heated to 260 ^{o}C and above. The pump may have overheated, ensure that you observe the appropriate safety precautions to prevent contact with any residual gases, the seals and any other contaminated components.
- Ensure that no components are omitted or incorrectly fitted during the reassembly of the pump.

5.2 Maintenance plan

The plan shown in Table 5 lists the maintenance operations necessary to maintain the SI100 pump in normal use. Instructions for each operation are given in the section shown.

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

Operation	Frequency	Refer to Section
Check the pump fluid level	6 monthly	5.3
Inspect the pump fluid (and drain if necessary)	As required	5.4
Clean the pump	6 monthly	5.5
Clean the radiation shield	6 monthly	5.6
Replace the pump heater	As required	5.7
Check the operation of the inlet-baffle	As required	5.8
Check the operation of the thermal snap-switches	6 monthly	5.9

Table 5 - Maintenance plan

5.3 Check the pump fluid level

If the SI100 pump fails to give satisfactory performance on a leak tight system, use the procedure below to check the level of fluid in the boiler.

1. Disconnect the pump from your vacuum system.
2. Refer to Figure 2. Undo and remove the four fixing screws (1) and remove the inlet-baffle assembly (20). Note you may need to loosen the four screws which secure the fan cowl (Figure 1, item 17) to do this.
3. Remove the transit spring (19) and the interior assembly (the top-jet cap (16), and the upper and lower jet-stages (14 and 12)).
4. Use a suitable tool as a dipstick to measure the depth of pump fluid in the base of the pump, next to the heater (9). Measure the fluid depth both sides of the heater. If the two depths are different, tilt the pump away from the heater electrical cable, return the pump to the vertical and then measure the fluid depths again.
5. If the average depth of pump fluid in the boiler is below 13 mm, pour more fluid into the pump (refer to Section 3) until the correct depth of fluid is achieved.
6. Refit the interior assembly in the pump, then refit the transit spring (19).
7. Refit the inlet-baffle assembly (20) and secure with the four fixing screws (1); ensure that the inlet-baffle ‘O’ ring (21) is correctly located in the assembly.
8. Ensure that the screws which secure the fan cowl (Figure 1, item 17) are secure.
9. Refit the pump to the vacuum system as described in Section 3.

5.4 Inspect the pump fluid (and drain if necessary)

If the pump fails to give satisfactory performance on a leak tight system, inspect the condition of the pump fluid. Use the following procedure.

1. If the pump is cold, switch on the pump heater for a maximum of two minutes to warm the pump fluid. Do not vaporise the pump fluid.
2. Disconnect the pump from your vacuum system.
3. Remove the inlet-baffle assembly (Figure 2, item 20): refer to Step 2 of Section 5.3.
4. Look at 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 5.5.

   If the interior of the pump is in a satisfactory condition, refill the pump as described in Section 3. Reassemble the pump as described in Steps 7 and 8 of Section 5.3 and refit the pump to your vacuum system as described in Section 3.

5.5 Inspect and clean the pump

5.5.1 Dismantle the pump

1. Disconnect the pump from your vacuum system.
2. Refer to Figure 1. Disconnect the heater electrical supply cable (11), the cooling-fan electrical supply cable (4) and the inlet-baffle electrical supply cable (18) from the electrical supplies.
3. Undo and remove the four screws (17) which secure the fan-cowl and remove the fan- cowl and cooling-fan (5) from the pump.
4. Refer to Figure 2. Undo the four fixing screws (1) and remove the inlet-baffle assembly (20) and the inlet-baffle 'O' ring (21). Note that you may need to loosen the four screws that secure the fan cowl (Figure 1, item 17) to do this.
5. Remove the transit spring (19) and the interior assembly (the top-jet cap (16) and the upper and lower jet-stages (14 and 12)).
6. Tilt the pump away from the backing connection and carefully pour the pump fluid out through the pump inlet flange(3) into a suitable container.
7. Remove the pump body 'O' ring (17).
8. Undo and remove the nut and washer (10) and remove the lower and upper stages (12 and 14) from the top-jet cap (16). Unscrew the tie-rod (15) to remove it from the top-jet cap (16).
9. Refer to Figure 1. If fitted, undo and remove the screws (16) which secure the cooling-fail thermal snap-switch (15) to the pump and remove the snap-switch.
10. Undo and remove the screws (10) which secure the radiation shield (9) and remove the radiation shield from the pump.

5.5.2 Inspect and clean the interior

> CAUTION
>
> Remove all traces of the cleaning solution before you operate the pump. If you do not, the performance of the pump will be poor.

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

1. Wash the pump body (11) and backing condenser (6) with the selected cleaning solution.
2. Immerse the pump body in a vapour degreasing bath. If a vapour degreasing bath is not available, wash the interior of the pump with a suitable cleaning solution.
3. Wash again with acetone to remove all traces of the cleaning solution. Bake to 77 ^{o}C to remove the acetone. Alternatively, pass warm air over the components and the pump interior.
4. Clean the spring and the components of the dismantled in Section 5.5.1 only by the method described in Steps 2 and 3. Do not use any abrasive or reactive chemical cleaner as this will impair the performance of the pump.
5. Refer to Figure 2. Wash the inlet-baffle assembly (20) with a suitable cleaning solution to clean it, then remove the cleaning solution as described in Step 3.
6. Inspect the inlet 'O' ring, the inlet-baffle 'O' ring (21) and the pump body 'O' ring (17) for damage or deterioration and replace them if they are defective.
7. Check that all sealing faces are free from scratches and other damage. Refinish surfaces that are scratched.

5.5.3 Reassemble the pump

1. Refer to Figure 1. Refit the radiation shield (9) and secure with the screws (10).
2. Refer to Figure 2. Refit the tie-rod (15) to the top-jet cap (16).
3. Refit the upper and lower jet-stages (14 and 12) to the top-jet cap, then refit the nut and washer (10) to secure the interior assembly.
4. Refit the interior assembly and the transit spring (19) in the pump body, then refit the pump body 'O' ring (17) to the pump.
5. Refit the inlet-baffle assembly (20); ensure that the inlet-baffle 'O' ring (21) is correctly positioned. Use the screws (1) to secure the inlet-baffle to the pump.
6. Refer to Figure 1. Refit the fan-cowl and cooling-fan (5) to the pump and secure with the four screws (17).
7. Leak test the pump, fill the pump with fluid, refit the cooling-fail thermal snap-switch (if removed in Section 5.5.1) and refit the pump to your vacuum system as described in Section 3.

5.6 Clean the radiation shield

Keep the radiation shield around the boiler clean to maintain thermal efficiency. To clean the external surface of the radiation shield, isolate the pump from the electrical supply and allow the pump to cool. Use a soft cloth (and a suitable cleaning solution, if necessary) to wipe the radiation shield. If you need to clean the internal surface of the radiation shield, remove the securing screws and remove the shield. Clean the interior of the shield and refit it.

5.7 Replace the pump heater

> WARNING
>
> Do not allow anti-seize compound to come into contact with electrical cables. If you do, the cables may be damaged and there may be a risk of electric shock.

> CAUTION
>
> Do not use a solid drift to remove the pump heater. If you do, you will force the pump heater to be more tightly held within the housing tube.

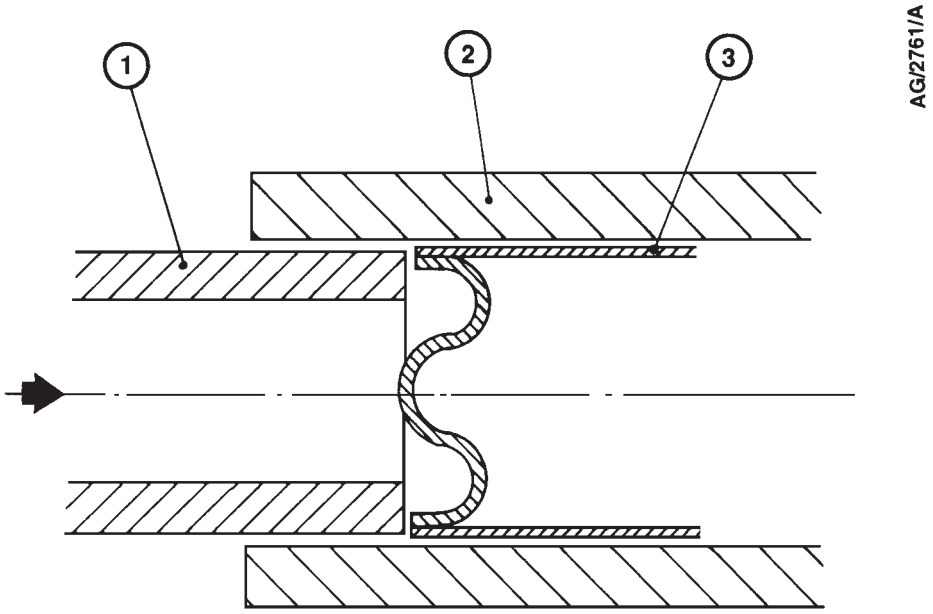
Replace the pump heater as described below. When you replace the pump heater, we recommend that you check the condition and quantity of the fluid charge.

1. Undo the four screws (10) which secure the radiation shield (9) and remove the radiation shield from the pump.
2. Refer to Figure 5. Apply a penetrating oil to the end of the heater housing tube (2) which has no electrical connections. Allow two to three hours for the penetrating oil to act.
3. Hold a hollow steel drift (of outside diameter between 9.5 mm and 9.7 mm and wall thickness of between 1.5 mm and 3 mm) in position as shown in Figure 5. Tap the drift sharply with a hammer, until the pump heater (2) moves freely in the housing tube (2).
4. Remove and discard the old pump heater.
5. Lightly coat the surface of the new pump heater with a copper or graphite based high temperature anti-seize compound.
6. Insert the pump heater into the housing tube (see Figure 6) and then remove it. Insert and remove the pump heater two or three times to ensure that there is an even coating of anti-seize compound on the pump heater and on the inner surface of the housing tube. When there is an even coating, leave the pump heater in the housing tube.
7. Turn the threaded heater boss so that the slots in the boss align with the radiation shield.
8. Refer to Figure 1. Refit the radiation shield (9); ensure that it locates correctly in the slots in the heater boss. Refit the screws (10) to secure the radiation shield.
9. Refit the pump to your vacuum system as described in Section 3.

5.8 Check the operation of the inlet-baffle

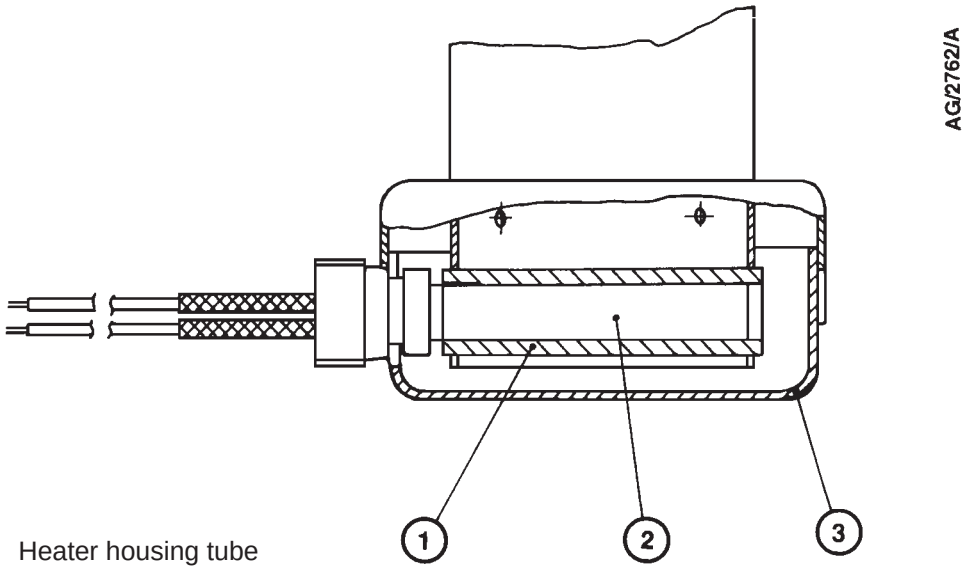
1. Disconnect the pump from your vacuum system.
2. Connect the cooling-fan electrical supply cable (Figure 1, item 4) to a suitable electrical supply, then switch on the electrical supply.
3. Connect the inlet-baffle electrical supply cable (Figure 1, item 18) to a suitable electrical supply, then switch on the electrical supply.
4. Use a thermocouple to measure the temperature of the inlet-baffle. After approximately 20 minutes, the inlet-baffle temperature should be about 15 oC below ambient temperature.
5. If there is no change in the temperature or if the inlet-baffle temperature is less than 10 ^{o}C below the ambient temperature, continue at Step 6 to replace the thermoelectric device. Otherwise, continue at Step 17.
6. Disconnect the inlet-baffle from the electrical supply.
7. Refer to Figure 2. Undo and remove the fixing screws (1) and remove the inlet-baffle (20) from the pump.
8. Remove the thermoelectric device (2) from the inlet-baffle.
9. To identify the hot and cold sides of the new thermoelectric device:
   - Apply a suitable thermal compound to one face of the new thermoelectric device (2) and fit it to the inlet-baffle.
   - Repeat Step 3.
   - If the inlet-baffle is cooled, continue at Step 10.
   - If the inlet-baffle is heated, switch off the electrical supply to the inlet-baffle (thermoelectric device).
   - Remove the thermoelectric device from the inlet-baffle.
   - Apply the thermal compound to the other face of the thermoelectric device. Fit it to the inlet-baffle.
   - Repeat this Step (Step 9) from the second bullet point.
10. Disconnect the cooling-fan from the electrical supply.
11. Disconnect the thermoelectric device from the electrical supply. Carefully note which is the hot side of the thermoelectric device and then remove the device from the inlet-baffle.
12. Thread the electrical supply cable for the thermoelectric device through the leadthrough (18) in the pump.
13. Apply a suitable thermal compound to the hot side of the thermoelectric device and place this side down in the inlet-flange assembly (3).
14. Inspect the inlet-baffle ‘O’ ring (21); if the ‘O’ ring is damaged, replace it with a new one
15. Refit the inlet-baffle in the pump; ensure that the inlet-baffle ‘O’ ring (21) is correctly positioned.

(Continued on page 24)



1. Hollow drift
2. Heater housing tube
3. Heater cartridge

Figure 5 - Use of a drift to remove the heater cartridge



1. Heater housing tube
2. Heater cartridge
3. Radiation shield

Figure 6 - Cross-section view of the heater assembly

16. Use the three fixing screws (1) to secure the inlet-baffle. Tighten the screws gradually, in rotation. Finally, tighten each screw to a torque of 0.38 Nm.

17. Refit the pump in your system as described in Section 3.

5.9 Check the operation of the thermal snap-switch(es) (if itted)

If you have fitted a cooling-fail thermal snap-switch and / or a pump ready thermal snap-switch to the pump, you must check that each snap-switch operates correctly.

Disconnect the electrical supplies from the pump, then use the following procedure to check the operation of each snap-switch:

1. Remove the thermal snap-switch from the pump.

2. Place the thermal snap-switch on a temperature controlled surface and monitor the contacts for electrical continuity. Check that the contacts open and close at the correct temperatures: refer to the instruction manual for the snap-switch.

3. If the thermal snap-switch is defective, replace it.

4. Refit the thermal snap-switch to the pump as described in the instruction manual for the snap-switch.

After you have checked the snap-switch(es) for correct operation, reconnect the electrical supplies to the pump as described in Section 3.

5.10 Fault finding

Symptom	Check	Action
Poor ultimate pressure	Is there a leak in the vacuum system, virtual or real ?	Locate and rectify the leak.
	Is the vacuum system dirty ?	Clean the vacuum system.
	Is the pump fluid contaminated ?	Inspect the pump fluid. Clean and refill the pump if necessary.
	Is the heat input low or high ?	Check the electrical supply voltage. Check the heater cartridge for power rating, electrical continuity and poor thermal contact. Renew the heater cartridge if necessary.
	Is the backing pressure high ?	Check for a leak in the backing pipeline and for poor backing pump performance. Correct as necessary.
		Check for thermal breakdown of the pump fluid. Clean the pump and refill with fluid as necessary.
There are inlet pressure surges	Is the heater input incorrect ?	Check and rectify if necessary.
	Is the fluid outgassing ?	Inspect the condition of the pump fluid. Refill with new fluid as necessary.
	Is there a leak in the vacuum system before the SI100 inlet ?	Check and rectify, if necessary.
	Is there a trapped volume in the vacuum system ?	Check and rectify, if necessary.
	Is there too much lubrication oil on the 'O' ring, centring ring or Co-Seals ?	Check and rectify, if necessary.
	Is there too much fluid in the SI100 diffusion pump ?	Check the level of fluid in the pump. Drain the fluid if necessary.

Table 6 - Fault finding checklist

6 STORAGE AND DISPOSAL

6.1 Storage

Use the following procedure to store the pump:

1. Shut down the pump as described in Section 4.
2. Isolate the pump from the electrical supply, disconnect it from the vacuum system and drain the pump fluid as described in Section 5.
3. Dismantle, clean and reassemble the pump as described in Section 5. Do not refill the pump with fluid.
4. Place protective covers over the inlet and outlet flanges.
5. 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 SI100 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 ^{o}C (see Section 5)
- Components which have been contaminated with dangerous process substances.

7 SERVICE, SPARES AND ACCESSORIES

7.1 Introduction

BOC Edwards products, spares and accessories are available from BOC Edwards companies in Belgium, Brazil, China, France, Germany, Israel, Italy, Japan, Korea, Singapore, United Kingdom, U.S.A, and a world-wide network of distributors. The majority of these centres employ Service Engineers who have undergone comprehensive BOC Edwards training courses.

Order spare parts and accessories from your nearest BOC 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 part.

7.2 Service

BOC Edwards products are supported by a world-wide network of BOC 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 BOC 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 BOC Edwards company.

7.3 Spares

Spare	**Item Number**
Santovac 5 (500 ml)	H114-01-002
Cooling-fan:	
115 V	B223-01-015
240 V	B223-01-014
Inlet-baffle thermoelectric device	E219-03-002
Pump heater	
90 V a.c., 250 W	H017-07-075
180 V a.c., 200 W	H017-07-073
Pump-inlet ‘O’ ring / pump body ‘O’ ring	H021-06-153
Inlet-baffle ‘O’ ring	H021-06-063

7.4 Accessories

Accessory	Item Number
Cooling-fail thermal snap-switch	B279-03-006
Pump ready thermal snap-switch	B023-04-000