Technical Overview

Ion Pump Troubleshooting

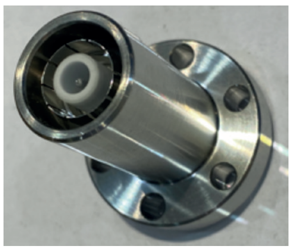
Most common cases: information on possible causes and solutions

The extensive lifetime and minimal required maintenance of Agilent ion pumps allow them to operate for long periods of time without the need for service.
The vast majority of cases, typically referred to as "issues" by Agilent ion pumps users, are resolved by being fixed in the field.
Other cases are the consequence of misuse with no need for service or pump return.
This technical overview provides information on possible causes, as well as clear instructions on how to identify and implement the right mitigation strategy for each of the most common issues. The overview covers pump starting, pump-down phase, system base pressure, and backout. It is designed for technicians looking for a quick reference guide to help them address possible problems with vacuum systems equipped with an ion pump.
By following the guidelines outlined in this document, users can reduce the system downtime, optimize ion pump performance, and dramatically reduce the need for service actions.

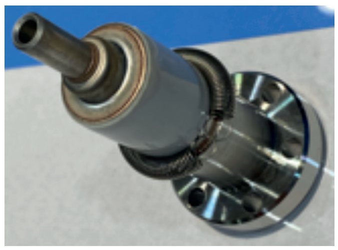
Case 1

Pump does not start
Maximum current with V=0

Possible Cause	To Verify	Solution
Short Circuit	- Check that the feedthrough (F/T) is undamaged - Check that the internal connections between the high voltage feedthrough and pumping elements are intact - Visual inspection and electrical insulation test	Replace the F/T (where possible and if damaged) or contact local office

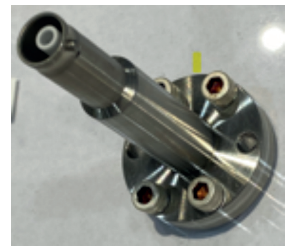


Fischer
9595125



Varian Diode (American)
9545143

StarCell
9595120



Kings 10kV (SHV)
X3601-68022

Solution

Electrical insulation test: short circuit

Two different tests can be performed to check for a short circuit:

- **Resistance test:** with a multimeter/ohmmeter, check for short circuits by measuring the resistance between the feedthrough tip and the pump body. Resistance should be infinite. This test may not be effective in finding a short circuit.
- **Electrical strength test:** this is a more reliable test performed with a rigidometer. This test is a measurement of "Dielectric rigidity," the maximum value that the electric field can assume before the discharge. It is carried out at atmospheric pressure and a value of 5 kV is set as the maximum voltage applied. If the pump does not show voltage discharges up to 3.5 kV, any abnormal electrical discharge or insulation problem can be excluded.

Remember that the "short circuit" message may appear on the controller for several reasons:

- Mechanical contact between the anode and the cathode (due to a mechanical shock to the pump) / presence of conductive material deposition on the insulating ceramic and lack of electrical insulation due to ceramic breakdown. The short-circuit current of the control unit will be drawn and low voltage will be indicated.
- Damage to the HV cable (e.g., due to inadvertent compression causing contact between the outer metal shield and the inner conductor) or a short circuit within the control unit. In this case, low voltage will also be observed when the high voltage connector is disconnected from the pump.
- Internal pressure too high (pump with internal pressure close to atmospheric pressure), recognized by the controller as an "overload" situation. In fact, when powering up, the controller supplies the maximum current (20 mA in IPCMini - 40 or 100 mA in 4UHV) which should correspond to a voltage of about 2000 V; but in high-pressure condition, when the voltage fails to rise above 200-250 V in few seconds, the short circuit message appears.

Case 2

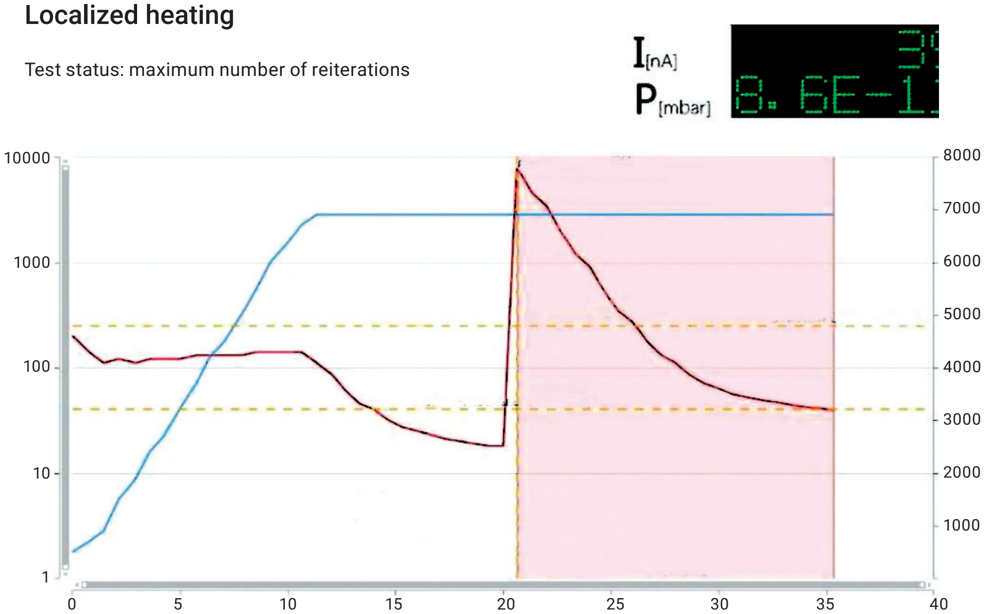
Pump does not start
Maximum voltage and low power

Possible Cause	To Verify	Solution
Pump magnets installed incorrectly or not suitable for pump specification	Verify magnets are installed correctly (N/S) and are those suggested by Agilent	Correct the position/kind of magnets
Wrong HV polarity	Check that the polarity of the control unit high voltage is correct for the pump being used. Diode and noble diode pumps require positive HV. Triode and StarCell pumps requite negative HV	
High voltage cable not properly connected	Check the cable-pump and cable-controller connections	
Pump at atmospheric pressure	When opening the pump, the ConFlat flange is removed without resistance	If the pump has not been contaminated inside, its use is not compromised
Failure of arc ignition due to excessively low internal P	Sudden decrease of current with value tending to zero	Promote priming by **localized heating** or gentle knock

Solution

Localized heating

Test status: maximum number of reiterations



Example of current trend in case of failure to trigger due to excessively low internal P.

Proceed by promoting the starting of discharge using a heat gun. Locate the heating as close as possible to the pumping elements and away from F/T, flanges, magnets, and pole pieces.

Case 3

Slow starting

Possible Cause	To Verify	Solution
Starting vacuum pressure too high/ insufficient roughing vacuum	Check roughing pump for correct operation, check roughing gauge	Reduce pressure to 10-5 Torr recommended 10-4 Torr minimum
Vacuum leak in the system or in the pump, which limits pressure to above 10^{-4} Torr	Leak check on vacuum system and ion pump (focusing on F/T area and welding areas)	In case of leak on ion pump, repair leak / replace F/T (if not welded) / replace the ion pump

Solution

Leak check

Using a mass spectrometer an equivalent type of leak detector, spray the outside surface of the system at suspected leak points with a probe gas through a fine muzzle.

If a leak detector is not available, a less desirable method of leak detection is to monitor the pump current in conjunction with using a probe gas such as helium and closing the pump flange and the gas probe in a plastic bag.

Case 4

Slow pump down

Possible Cause	To Verify	Solution
Pump magnets not suitable for pump specification or damaged	Verify magnets are those suggested by Agilent	Correct the kind of magnets
System not fully baked (atmospheric contaminants absorbed on pump and system internal surfaces)		**Bakeout** the system
Pump overheating due to too high pressure		Allow cooling to room temperature and adjust the prevacuum in the system
Leak in the system or in the pump	Leak check on vacuum system and ion pump (focusing on F/T area and welding areas)	In case of leak on ion pump, repair leak / replace F/T (if not welded) / replace the ion pump

Solution

Leak check

Using a mass spectrometer an equivalent type of leak detector, spray the outside surface of the system at suspected leak points with a probe gas through a fine muzzle.

If a leak detector is not available, a less desirable method of leak detection is to monitor the pump current in conjunction with using a probe gas such as helium and closing the pump flange and the gas probe in a plastic bag.

Case 5

System fails to achieve the desired stable vacuum pressure.
The ion current is too high

Possible Cause	To Verify	Solution
System not fully baked (atmospheric contaminants absorbed on pump and system walls)	Graph P vs. t : P drops quickly but the minimum limit is higher than normal	**Bakeout** the system to speed up the gas release from the walls
Insufficient degree of cleanliness in vacuum system	Graph P vs. t with many spikes	Careful cleaning of the interior of the vacuum system and pump
Microleak in ion pump or in the system	Leak check on vacuum system and ion pump (focusing on F/T area and welding areas)	In case of leak on ion pump, repair leak / replace F/T (if not welded) / replace the ion pump
Undersized pump with respect to the system		

Solution 1

Leak check

Using a mass spectrometer or an equivalent type of leak detector, spray the outside surface of the system at suspected leak points with a probe gas through a fine muzzle.

If a leak detector is not available, a less desirable method of leak detection is to monitor the pump current in conjunction with using a probe gas such as helium and closing the pump flange and the gas probe in a plastic bag.

Solution 2

Bakeout

Used to speed up the desorption of the water layers and, consequently, the pump-down.

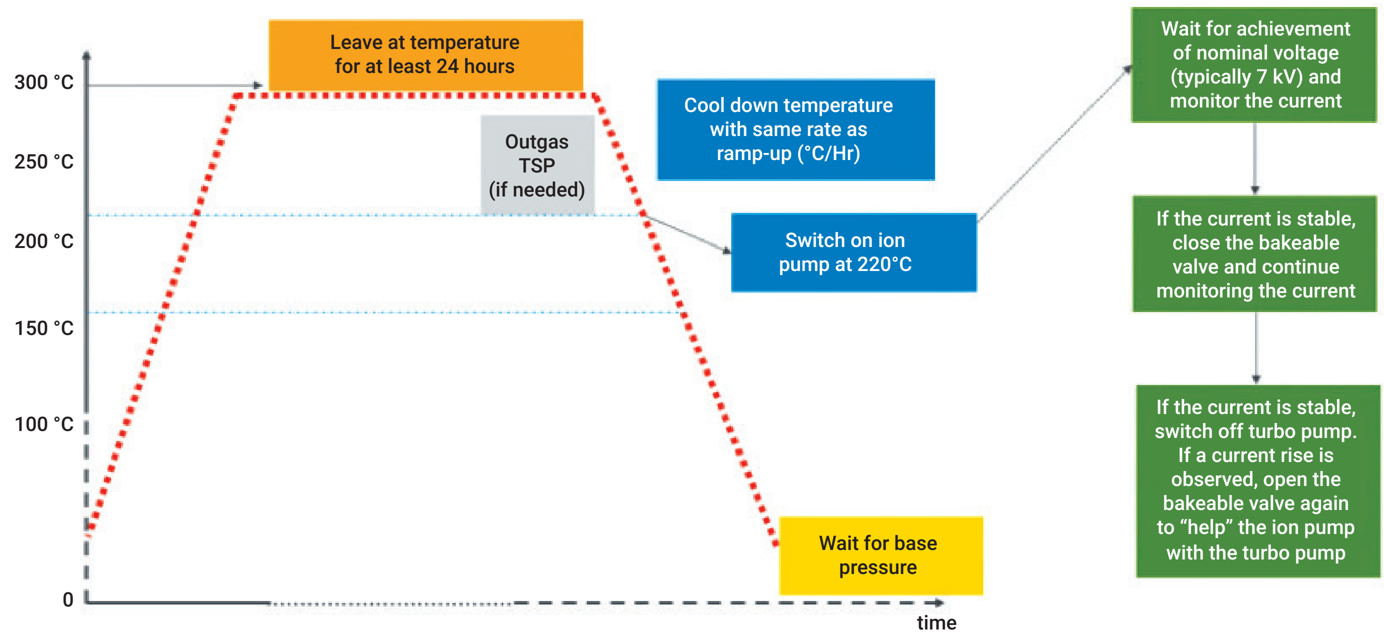
- Place the ion pump connected to the system under vacuum.
- Heat the pump body and the system with a bakeout oven unit / heating strips / integral heaters (the heating must be approximatively even on all surfaces).

Based on the specific system or needs, the bakeout operation can be done with the ion pump in operation or switched off:
Ion pump switched on: **T must be between 150 °C and 220 °C (220 °C is the maximum allowable for most bakeable high voltage cables).**

- Adjust the heat to prevent pressure in the system from rising above approximately 2×10^{-5} torr.
- Leave the pump control unit on and monitor the pressure. Agilent recommends that the current during bake does not exceed 25 mA; if this value is exceeded, turn the bakeout off and then on again when low pressure is restored.
- Bake the VacIon Plus pump for at least 24 hours (generally, an overnight bakeout of this sort will be sufficient, but longer bakeouts may be required for contaminated systems).
- As the pump and system cool down to room temperature, a drop in pressure should be observed.

Ion pump switched off: system connected to an auxiliary pump (i.e. turbo pump through a bakeable isolation valve);
T must be between 150 and 350 °C (higher T could damage the magnets). It is recommended to switch on the ion pump before complete cooling, below 220 °C.

The graph below shows:
- bakeouts at temperatures higher than 350 °C must be done with magnets removed from the pump.
- bakeouts in presence of any Viton seals should be limited to 150 °C.



Case 6

Ion pump current not proportional to pressure

Ion pump current higher than expected and system pressure at low levels expected

Possible Cause	To Verify	Solution
Electrical leakage current outside the pump, in the control unit, cables or connectors has developed	Check the control unit and cable independently of the ion pump	Eliminate the source of leakage current
Pump has developed high leakage current	Leakage current test	**Hi-potting** procedure

Solution 1

Eliminate the source of leakage current

After an extended operation of an ion pump, where sputtered material deposits may form flakes with sharp points, field emission leakage current may occur. This current results from electrons being extracted from sharp points under high voltages; it is totally independent of internal pressure and increases as the ion pump ages when sputtered deposits coat the ceramic insulators with a conductive film. It has a threshold and is exponentially related to the applied voltage above the threshold. Moreover, it depends on the distances between adjacent surfaces and the geometry of the field emission point.
The leakage current does not appreciably affect the pump operation or the pumping speed (on the contrary, it makes it easier to trigger), but it can mask the true ion current and make the pump incapable of giving accurate pressure readings.
However, pressure can be read by determining the total leakage current after removing the magnets and subtracting this value from the total current drawn by the pump.Other sources of leakage current:
- HV cable
- Controller
- Moisture between connector and feedthrough

Leakage current test:

To determine whether an ion pump current increase is due to an increase in system pressure or a leakage current/field emission, follow these steps:

- Place the system under a vacuum sufficient to produce 1 mA or less ion pump current
- Switch off the ion pump controller
- Remove the magnets from the ion pump (see Removing the Magnets procedure)
- Switch on the ion pump controller (3 kV). Current should be negligible on the ion pump controller
- If leakage current is present at 3 kV, maintenance may be required

Solution 2

Hi-potting procedure

The reduction or removal of a field emission leakage current is accomplished by a process called “hi-potting,” applicable only if a particular Hi-potting device able to deliver voltages above 7kV AC is available or if a technical service can be used to perform the procedure in situ. Taking advantage of the exponentially increasing current with applied voltage, the sharp points/whiskers can be burned off by applying the over-voltage to the pump. Please follow these steps:
- Connect the hi-potting device to the ion pump
- With the pump pressure in the low micron range (10^{-2} torr), turn on the control unit
- Several applications of this technique may be necessary. Be sure to allow the control unit to discharge completely between each application

If hi-potting does not reduce the leakage current to appropriately low values, then the pump probably needs rebuilding due to the conductive coating on insulator surfaces.

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