Gate Valve for Replacement of Inlet Capillaries in Agilent Triple Quadrupoles without Venting the Mass Spectrometer

Technical Overview

Introduction

Installation of a gate valve between the ion source and high vacuum region of a mass spectrometer (MS) facilitates cleaning and maintenance of ion source optics and inlet ion transfer capillaries while maintaining high vacuum conditions, and minimizing downtime. In addition to an adequate vacuum sealing mechanism, gate valves should operate with minimum moving parts, and not contribute to ion transmission losses.

This Technical Overview introduces a novel and cost-effective gate valve design for replacing resistive glass capillaries (RGCs) in Agilent triple quadrupole MS systems (equipped with ion funnels) without breaking MS high vacuum pressure.

The newly designed gate valve assembly offers the following features:

- **Vent prevent maintenance:** With the gate valve installed, there is no need to vent the whole vacuum manifold for routine maintenance involving inlet capillary cleaning and replacement. Therefore, the instrument maintenance downtime is minimized, and laboratory efficiency increases. Conducting a capillary replacement with the gate valve may take only 20–30 minutes, versus at least 6 hours when venting and pumping down the instrument with no gate valve.
- **Robust operation:** The gate valve can withstand thousands of opening and closing cycles without the loss of vacuum seal or interruption in operation.
- **Maintenance-free operation:** The reduction in moving components minimizes wear and particulate generation, and reduces the need for maintenance.

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Results and Discussion

Gate valve design

The newly designed gate valve is a vacuum-tight chamber and part of the desolvation assembly in Agilent triple quadrupole MS systems equipped with ion funnels and 90-mm hexabore RGCs. The design of the gate valve involves minimal hardware changes to an existing Agilent 6495B Triple Quadrupole MS system, and adds no extra dimension to the desolvation assembly. The gate valve has one moving part, and includes a body and a blade (both made of PEEK), a stainless steel shaft attached to the blade, and an aluminum knob attached to the shaft for moving the gate valve blade into open and closed positions.

The use of an appropriate material in the gate valve assembly ensures minimum outgassing under vacuum and operational drying gas temperatures while maintaining a vacuum seal.

Figure 1 shows the gate valve as part of the 6495B Triple Quadrupole desolvation assembly.

A capillary puller tool was also designed for easy/safe removal of RGCs when using the gate valve for capillary replacement. Figure 2 shows a capillary puller tool. A knob on the capillary puller can be turned so that the collet will grab the end of the capillary facing towards the ion source. A stop is designed into the puller so that the collet stops at 39 mm, where the capillary is still sealed on the desolvation chamber when it is pulled all the way out.

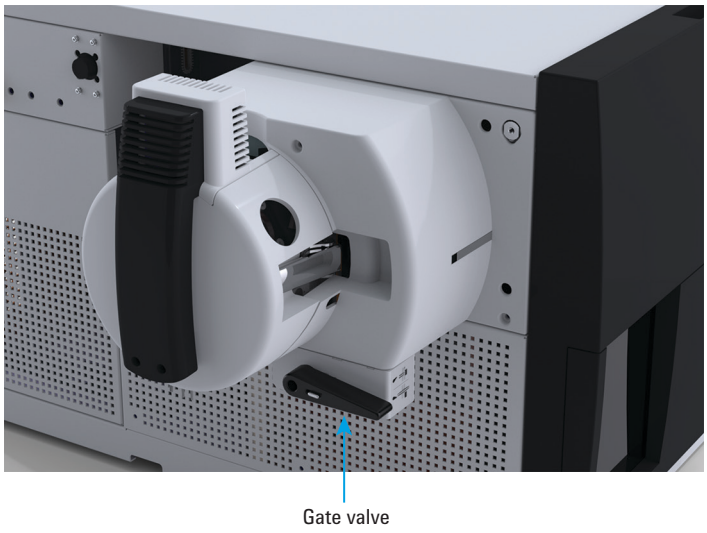

Figure 1. A gate valve installed on an Agilent 6495B Triple Quadrupole MS system.

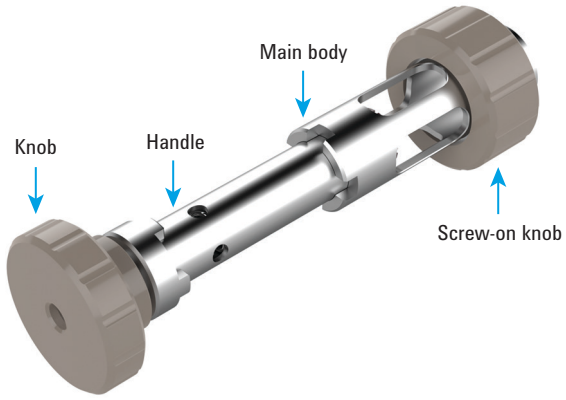

Figure 2. Capillary puller tool in pulled-out position.

Gate valve usage and operation

To remove an inlet capillary:

1. Cool the source by opening the AJS source door, and place the instrument in standby mode for 10 to 15 minutes.
2. Remove the spray shield and capillary cap.
3. Screw the capillary puller tool into the spray shield.
4. Push the capillary puller to the locked position. While in the locked position, turn the capillary puller knob clockwise to a full stop. At this step, the capillary puller collet grabs the end of capillary that is facing towards the ion source.
5. Pull the capillary puller knob out to a complete stop.
6. Move the gate valve handle up to bring the gate valve to the closed position (that is, no air flow into the vacuum manifold).
7. Unscrew the capillary puller, and remove the capillary.

To install an inlet capillary:

1. With the gate valve in the closed position, insert the capillary into the desolvation chamber to a full stop.
2. Move the gate valve handle down, to bring the gate valve to the open position.
3. Push the capillary into the desolvation chamber to a full stop.
4. Install the spray shield.
5. Close the AJS source door.

The system is ready to use.

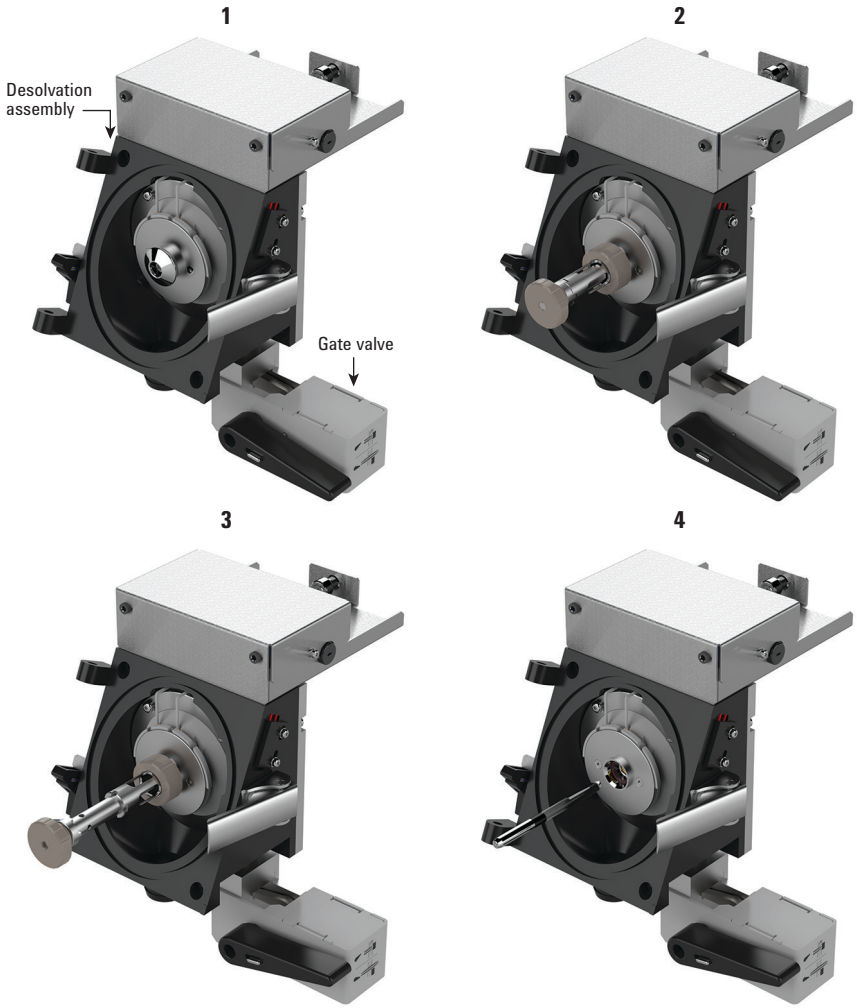

Figure 3. Removing inlet capillary using the gate valve without venting the triple quadrupole MS system.

Gate valve robustness evaluation

Figure 4 shows a plot of the rough vacuum pressure with (a) the gate valve open and the capillary installed, and (b) the gate valve closed and the capillary removed as a function of the number of opening/closing cycles of a gate valve installed on a 6495B Triple Quadrupole MS system. Each data point is an average of 25 measurements from installing and removing a hexabore capillary, and opening and closing the gate vale.

Figure 4 shows that there is no significant change in the rough vacuum pressure for up to 500 gate valve opening/closing cycles, indicating that the vacuum sealing property of the gate valve does not degrade with use. There is a small air leak (virtual leak) through the gate valve into the vacuum manifold (that is, data recorded when the gate valve is closed and the capillary is removed), ensuring that no rough vacuum pump oil backstreams to the vacuum manifold.

Data in Figure 5 show no performance degradation when using a gate valve assembly on a 6495B Triple Quadrupole MS system. Data were obtained by infusing Agilent tune mix solution, and recording the abundances for each *m/z* in positive and negative ion modes. There is no change in tune mass ion abundance with and without gate valve assembly.

Conclusions

The newly designed gate valve assembly in Agilent 6495B Triple Quadrupole MS systems allows inlet ion transfer capillary replacement without venting the mass spectrometer, and minimizes the maintenance downtime of the instrument.

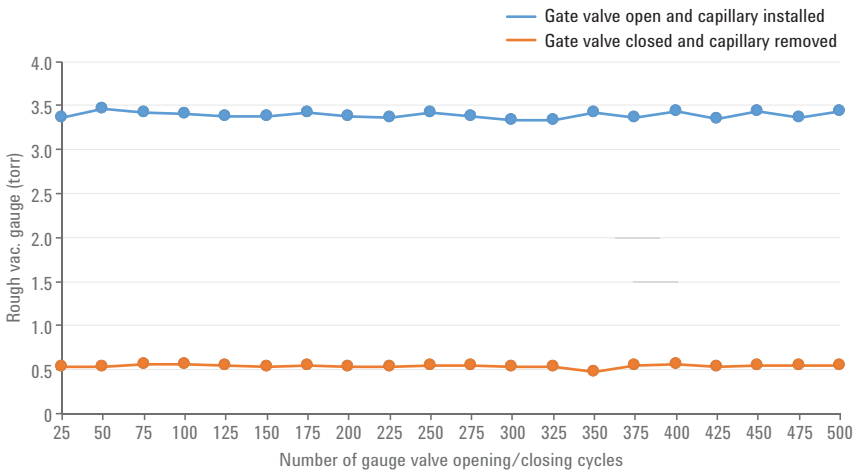

Figure 4. Rough vacuum pressure as a function of opening/closing cycles of a gate valve installed on an Agilent 6495B Triple Quadrupole MS system.

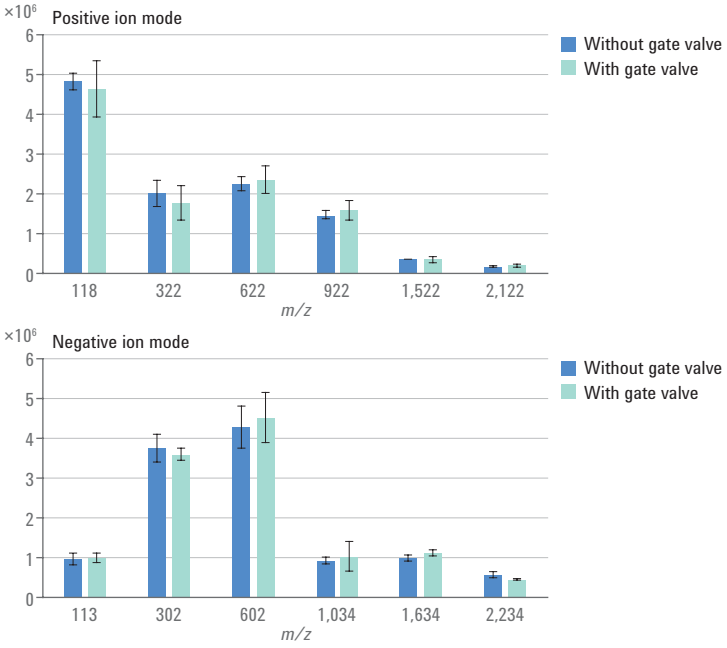

Figure 5. Agilent tune mix ion abundance with and without the gate valve installed.

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Published in the USA, January 24, 2017
5991-7735EN

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