Compact UHV Valve with Field Replaceable Windows*

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ABSTRACT

There are many applications in synchrotron radiation research where window valves can be usefully employed. Examples include gas cells for monochromator calibration, filters for high order light rejection, and as vacuum isolation elements between machine and experimental vacua. Often these devices are fairly expensive, and have only fixed (ie non-removable) windows. The development of a new type of seal technology by VAT for their series 01 valves provides a gate surface which is free from obstructions due to internal mechanical elements. This feature allows a threaded recess to be machined into the gate to receive a removable window frame which can carry standard size Luxel thin film windows. The combination of these features results in a DN 40 (2.75" conflat flange) valve which provides a clear aperture of 21mm diameter for the window material.

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INTRODUCTION

Window valves of various types have been commercially available for some time, although they are often regarded as "special run" items. One popular type is a "straight through" plunger or poppet style valve which has been fitted with a fixed window (often of quartz or sapphire) as part of the poppet. One potential advantage of the straight through design is the possibility of orienting the window material at Brewsters angle, since the plunger is canted off the line of sight axis. This could be an important feature for applications where the valve is intended as an alignment aid with visible light. For many applications however, this type of device is not without its problems. First, the window material is selected at the time of manufacture with no provision for interchanging windows in the field. A second problem can be its size as compared to its clear aperture. One popular model [1] is fitted with DN 40 (2.75" CFF) flanges and is nearly 160 mm flange face to flange face, yet it provides a clear aperture of only 8 mm diameter.

The venerable gate valve has also been adapted for use as a window valve. In its more familiar form, it has the advantage of small dimension along the valve axis, but its disadvantage for this application is the mechanism associated with making the gate seal. It is often fairly difficult to modify the mechanism to allow a clear line of sight for a window, and the aperture provided (as compared to the valve aperture) is fairly small. A typical example [2] is fitted with DN 40 (2.75" CFF) flanges, is 72 mm flange face to flange face, and provides an aperture of 8 mm diameter.

Both types of valves are available as all metal devices (including the sealing surfaces), and each has important applications in synchrotron radiation research [3]. The advent of high resolution soft x-ray instruments has however presented the need for a different kind of window valve. One problem which has arisen from this new generation of high resolution monochromators is that of characterizing (and optimizing) their performance. Since some of these instruments are capable of resolving powers in excess of 10,000 at 400 eV, one must resort to gas phase measurements to obtain meaningful data [4].

Experience with the development of such a beamline [5] at the NSLS has demonstrated the importance of having a gas cell during commissioning, and motivated us to find a means of integrating one into the beamline for routine calibration and characterization of performance. It is desirable to do so in a way which does not require removal or significant interruption of an active experiment. One obvious way to achieve this objective is to isolate a small section of the beamline with window valves, back fill the cell with some suitable dry gas, and use either the IO monitor or the detector in the active experiment to perform an absorption measurement. These valves could also be used for their filtering properties (to remove soft scattered radiation) and as isolation of High Vacua experiments from the UHV beamline [6].

Some parameters of such a device are determined by the fact that it is installed on a beamline which is utilized for soft x-ray spectroscopies ($E < 1\text{keV}$). The window materials must allow some reasonable fraction of the incident x-rays to be transmitted (implying thin windows). In addition, they must be able to support a pressure differential of several hundreds of Pa (10's of Torr) to provide some absorption in the gas in a reasonable path length. Since several different gases might be employed to get energy calibrations at several energies, interchangeable windows (to avoid spectral interferences) would be desirable. In general, the components must be UHV compatible so as not to interfere with the function of the experiment, optical system, or the storage ring itself. And, as ever, minimal cost is a desirable goal.

For our purposes a gate valve provides the most compact package, and since the valve is not intended to seal and be baked while holding off atmospheric pressure, a valve design with viton gate sealing would be acceptable. To ensure UHV operation, however, a metal bonnet seal is required. Viton seals could also obviously be employed for sealing of suitably mounted windows to the valve gate. With these objectives and conditions in mind, we pursued the development of a commercial manual gate valve which could be readily modified to suit our applications.

VALVE CONSTRUCTION

The VAT series 01 valve was chosen because it is compact yet offers an easily exchanged and relatively large window to be mounted in the gate. Using a unique seal technology trade named MONOVAT, the valve measures only 35 mm flange-to-flange and employs virtually one moving part in the vacuum, a specially shaped gate plate with a Viton seal vulcanized directly to its edge. By eliminating complex and interfering lifting cams or bearings, the design frees the majority of the gate area for the window mounting and aperture, and provides nearly particle free and shock free operation. UHV compatibility is provided by a metal bonnet seal and stainless steel bellows, and enhanced by the vulcanized seal which eliminates o-ring problems such as the trapped volume under the seal or pulling out after baking.

For our application, the valve is modified by boring a clearance hole 21 mm in diameter through the gate plate, and machining a counterbore 2.5 mm into the face which has an internal M30x1 thread. A groove is machined into the face of the counterbore and window frame to accept a viton o-ring which provides the seal for the window. Both window frames (described in the next section), and blank inserts for mounting user configured windows have been made thus far. The only constraints on the size of other types of windows (for the DN 40 valve) is that in general they should not interfere with the sealing area which limits diameter to roughly 21.5 mm, or be any thicker than the valve gate (ca. 4 mm). As described, this valve is now available from VAT [7].

FILTER MOUNTING AND CONSTRUCTION

For our initial work we selected a window with a 1500 Angstrom thick Al/1%Si foil supported on stainless steel mesh. This material has fairly high overall transmission in the energy range of interest, yet is robust enough to withstand pressure differentials as high as 6650 Pa (50 Torr). Luxel mounts films of this type on many styles of standardized holders. It was determined that the mount ring from a TF-111 type holder was suitably sized for mounting in a machined window insert (figure 1) which mates to the valve gate. This design was specified as the insert to be supplied with the valve, so a thin film window can be fitted to it by Luxel [8].

The window material is made by the same techniques used to manufacture many Luxel EUV and x-ray filters. The aluminum (or other user defined filter material) is vacuum deposited on a substrate. Mesh is then applied to the metal foil using minute quantities of epoxy such that there will be no discernable effect on x-ray transmission. The mesh supported foil is then applied to the filter inner ring, and the inner ring is epoxied into the outer filter frame, thus producing the completed window insert for the valve. All epoxies used are UHV compatible. Tooling is utilized to apply the materials under uniform conditions to produce consistent filters

of high quality. Care is taken to insure uniformity such that there should be no stress concentrations in the foil when the filter is installed in the valve.

Since, for our applications, the window is located after the monochromator, cooling of thin film window during high resolution operation is not required. To interchange windows, a special spanner wrench is used which has two pins to index with the holes on the face of the window frame, and is nearly as wide as the valve clear aperture. Using this tool, we have thus far avoided accidental puncture of the windows while mounting them.

SUMMARY

The end result of this work is shown in figure 2. From our experience with the first four prototype versions thus far, the combination of valve and window has met all of our requirements. The threaded filter holder has proved so convenient that it is finding uses in other applications. For example we have started using them to suppress soft scattered light in some experiments [6]. A simple paddle 15 mm thick with an M30x1 hole threaded through it allows the series mounting of several filters of different materials as required for the particular experiment. Because of the sealing capability of the filter holder, we also intend to use them for the windows on our next generation of gas proportional counters.

Overall, this project has provided several useful components for our research program which are now commercially available to other researchers in the field at relatively modest cost.

ACKNOWLEDGEMENTS

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REFERENCES

- [1] Window Valve PN CSD25SV, Vacuum Generators Ltd. Sussex UK, Quoted Price Delivered to LI NY 7/91 \$2040 (US).
- [2] Window Valve PN 48436-CE01, VAT Aktiengesellschaft Haag Switzerland, Quoted Price Delivered to LI NY 7/91 \$6200 (US).
- [3] Note that no specific endorsement of these or any other products is intended. Those cited in refs 1&2 are included only because they provide familiar examples of the types of equipment which could in principle perform some of the functions of the device described in this article.
- [4] C.T. Chen and F. Sette, Rev. Sci. Instrum. 60 (1989) 1616.
- [5] U13U Spectroscopy Beamline at the NSLS, S.L. Hulbert, unpublished results.
- [6] E.D. Johnson, C.-C. Kao, and J.B. Hastings, Advances in soft x-ray scattering, these proceedings.
- [7] Valve is available from VAT as PN 01032-UE01-X Quoted Price (including window frame) Delivered to LI NY 7/91 \$1050.
- [8] 1500 A thick Al/1%Si window supported on Stainless Steel mesh mounted in frame supplied with valve; Delivered to LI NY 7/91 \$650. While Al/1%Si was selected for this work, several other "standard" films are available including Indium, Al:Si/C, TiN:3%Ge, Al:Si/Ti, Carbon, Boron, and Lexan. Custom fabricated materials can also be provided.

NSLS BEAMLINE R&D

For Parker 020 Viton or
Equiv. 21.95 ID, 1.78 CS

Revised 20 April 90
Specify O-ring
Call out Frame and mount
ring thickness
EDJ

VAT SERIES ONE VALVE FILTER FRAME
LUXEL VF-111 (NSLS ASSIGNED NUMBER)
USED ON VAT PN 01032-UE01-X
MATERIAL 304 STAINLESS STEEL
SCALE 3:1 21 March 1990 EDJ