A New type of Kapton® Window Holder

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Brief

Polyimide film, also known as Kapton®, is a robust material with several useful properties that allow it to be used as a transparent vacuum barrier for passing 500 eV or higher energy X-rays in process or research applications. Up to now, the use of Kapton® film as an X-ray window necessitated that the film be adhered directly to a metallic port flange or aperture.

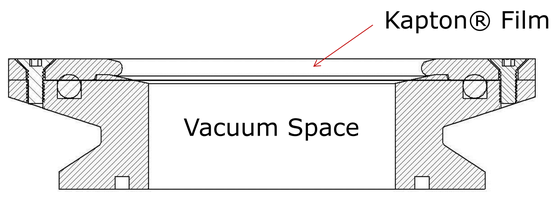
A new type of Kapton® window holder that does not require adhesive but that employs direct clamping force to retain the film against atmospheric pressure would permit rapid film replacement at the slightest hint of damage to avoid vacuum degradation.

Keywords: Kapton® film, X-ray, vacuum

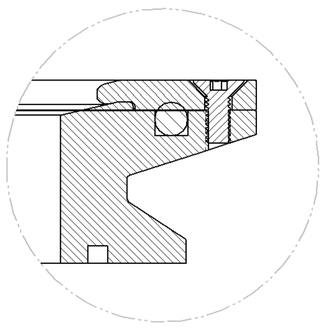
Design Research

Problem:
The process of removing an old Kapton® film and replacing it with a new one is both time-consuming and inconsistent and may lead to air leaks or delamination with prolonged or repeated use. This is because the adhesive, a 2-part epoxy, is usually hand mixed and applied with sometimes marginal, inconsistent results.

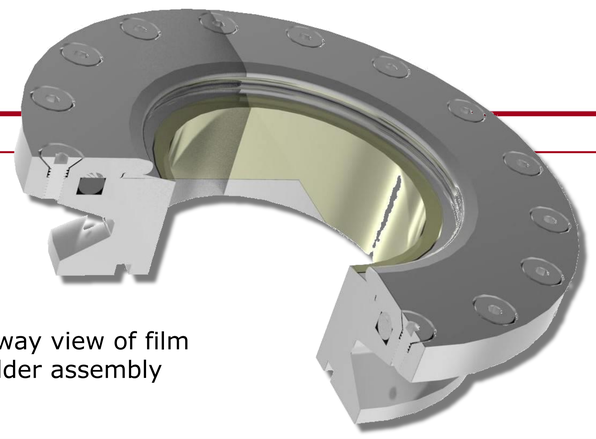
Solution:
A new type of film holder was designed to both capture the film in place and to seal the window hermetically.



The new design takes an existing KF63 flange design and adds .05” to the internal to permit a Z-profile feature that captures the Kapton® film by forcing it to conform when clamped. Additionally, an O-ring groove was added to eliminate the atmospheric leak path into the vacuum space. Lastly, a 13^0 inclined plane feature eliminates a sharp drop off when the film is under atmospheric load by tracing the natural deflection of the film.



Sectional view of O-ring and Film-clamping features



Cutaway view of film holder assembly

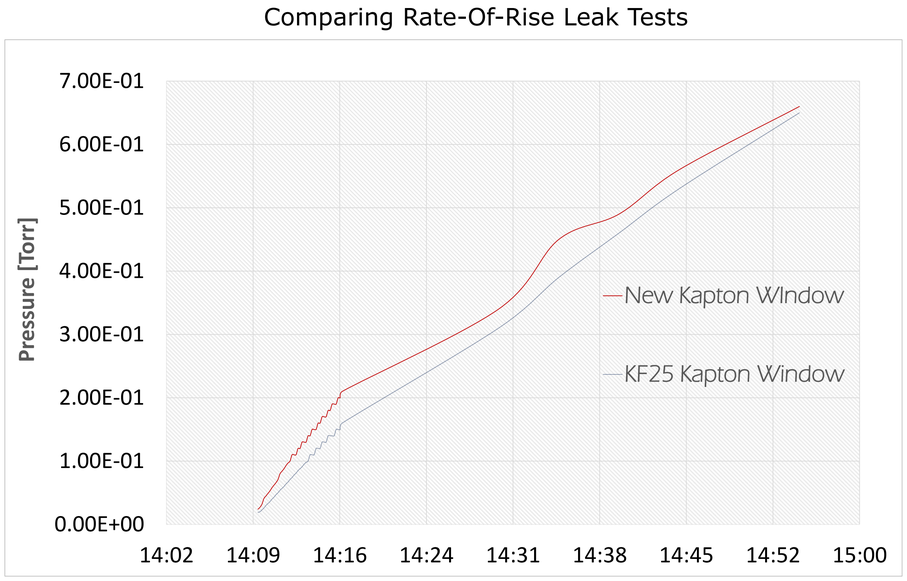
Proof of Concept

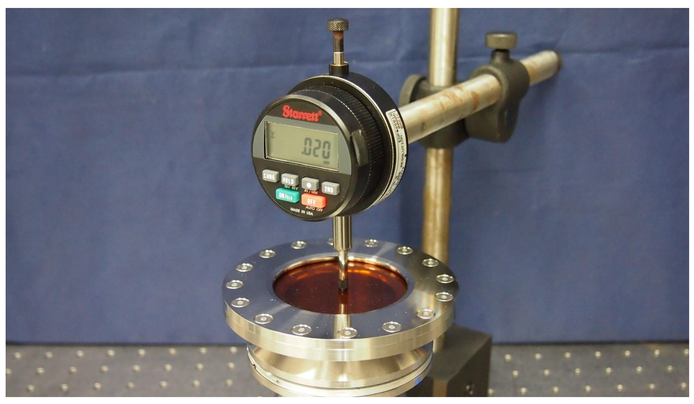
Assessing the reliability of the new Kapton® window holder design required two tests: a vacuum leak test and a film steadfastness test.

Initially, a helium-leak test was performed, but the permeation through the Kapton® film caused the detector to level out around 5E-7torr/l/sec. As a control sample, an existing KF25 flange with an epoxied Kapton® film was also leak tested. The permeation was detected to the same level as the new film holder confirming the relative insensitivity of the helium leak test for this purpose.

Vacuum leak and film steadfastness testing setup

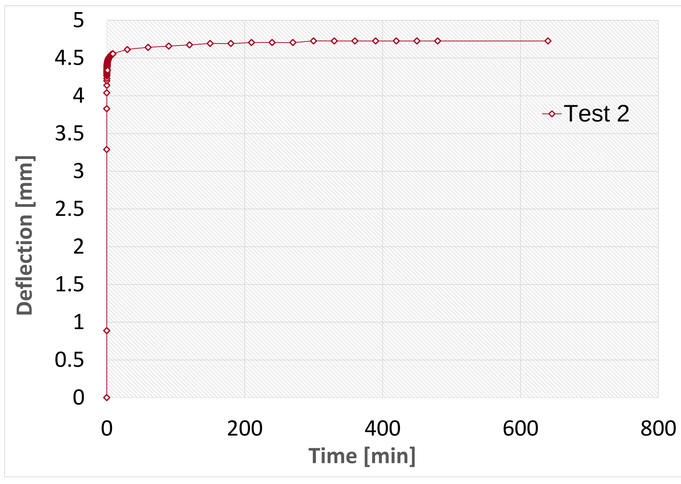
A rate-of-rise leak test was performed on both, the new film holder and the existing KF25 Kapton® film window. In each case, the resulting curve shape and slope indicates similar vacuum performance, i.e, both Kapton® window holder designs exhibit a relatively vacuum-tight condition. This test verifies that the O-ring seal is tight.





To test the holding performance of the new window holder’s clamp design, a rigid fixture incorporating a digital dial indicator was assembled for the purpose of detecting and measuring the magnitude of film deflection as a function of time and whilst the assembly was under vacuum.

During the measurement period, a sudden or unexpected increase in deflection could be interpreted as material creep through the clamping feature of the holder, thus signaling the possible failure of the Kapton® film’s steadfastness.



After two test runs, the data indicate that initial film elongation measured at the beginning of the chamber evacuation diminishes predictably and holds for the duration of the test, indicating that the grip function of the flange design works.

Conclusions

The new Kapton® window holder design was prototyped and tested to validate that the intended objective, that of the rapid change-out of the Kapton® film, was met.

The good performance of this design is encouraging and the special features therein are theoretically scalable to conform to both larger and smaller flange designs in order to accommodate a variety of applications.

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