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SECURITY CLASSIFICATION OF THIS PAGE

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REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704-0188 Exp Date Jun 30 1986

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS

2a

2b

3 DISTRIBUTION/AVAILABILITY OF REPORT: Published in open literature

4

AD-A196 712

5 MONITORING ORGANIZATION REPORT NUMBER(S)

6a NAME OF PERFORMING ORGANIZATION: Research Directorate, RD&EC US Army Missile Command

6b OFFICE SYMBOL (If applicable): AMSMI-RD-RE-QP

7a NAME OF MONITORING ORGANIZATION: same as 6a

6c. ADDRESS (City, State, and ZIP Code): Redstone Arsenal, AL 35898-5248

7b. ADDRESS (City, State, and ZIP Code): same as 6c

8a. NAME OF FUNDING/SPONSORING ORGANIZATION: same as 6a

8b OFFICE SYMBOL (If applicable): same as 6b

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code): same as 6c

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification): A SIMPLE AND RELIABLE VACUUM SEAL FOR OPTICAL WINDOWS (U)

12 PERSONAL AUTHOR(S): Stanley, A. E. and Grimley, R. T.

13a TYPE OF REPORT: Open-literature

13b TIME COVERED: FROM ______ TO ______

14 DATE OF REPORT (Year, Month, Day): 1988 January

15 PAGE COUNT: 2

16 SUPPLEMENTARY NOTATION: This paper was published in the open literature, in Journal of Applied Spectroscopy January 1988 Issue

17 COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number): Spectroscopic techniques; vacuum window seal.

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The paper describes the design and use of an improved vacuum seal for optical windows which eliminates the problems encountered in the use of conventional seals. Keywords:

Infrared Spectroscopy; Spectroscopes;

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☒ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: Uncl

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22c OFFICE SYMBOL: AMSMI-RD-RE-OP

A Simple and Reliable Vacuum Seal for Optical Windows

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Index Headings: Spectroscopic techniques; Vacuum window seal.

Recently, this laboratory has pursued[1-6] laser photochemistry as a controllable and cost-effective alternative for production of high-priority materials of Army need. In the course of these investigations we routinely do gas-phase irradiations in stainless steel cells (5 × 10 cm) equipped with O-ring seals for securing windows (5-cm diameter) onto the cells. We use ZnSe windows, which take the thermal stress induced by an infrared laser beam, on those windows through which we wish to irradiate a sample. The other windows are KCl or quartz, as defined by our experimental design. We have adopted some modifications into this cell which we would like to share with other spectroscopists in hopes these will be as beneficial to them as they have been to us.

In spectroscopic absorption cells designed for vacuum integrity, the techniques used to seal the optical windows are often time consuming and frequently result in the fracture of expensive optical flats. Two common variants of vacuum seal are found in both commercial and fabricated cells. In the most common designs an O-ring is mounted in a groove on the cell body, and the optical flat is squeezed against the O-ring to provide the vacuum seal. The manner in which the pressure is applied to the window has proven to be a major source of difficulty. One common configuration uses a retaining nut, which, when tightened, squeezes the window against the O-ring. Another means of exerting pressure on the optical flat involves the use of a capture plate bolted to the cell body. A gasket is used to prevent direct contact between the window and plate. There are a number of serious disadvantages to these types of seals. Tightening of the retaining nut can cause torquing of the window and O-ring, resulting in O-ring failure. In addition, the spacing between the metal seat of the cell body and the window cannot be determined precisely. As a consequence direct contact between the window and the metal seat may occur. The stresses developed by the application of uneven forces frequently result in the fracture of fragile windows. Further, the vacuum integrity of the seal must be determined by trial and error procedures, since the amount of compression cannot be determined accurately. The presence of multiple windows further complicates the identification of leak sites.

A simple window seal has been designed which eliminates the disadvantages mentioned above and is capable of maintaining pressures in a cell down to at least 10^{-7} Torr. This pressure is generally adequate for sample exchange in laser reaction or absorption cells. The design of the seal can be readily incorporated into cells of virtually any size or configuration. An exploded view and a cross-sectional view of the seal are shown in Figs. 1 and 2, respectively. For the best vacuum integrity, type 304 stainless steel (SS) or Inconel are recommended for construction of the cell proper or for any components in direct contact with the vacuum. In order to minimize cost and time, we tested the design by modifying an existing cell made of 303 SS. For most applications of this type, 303 SS is satisfactory, and offers the advantage of easier machining. The end of the cell body (F) and the trap flange (B), are 2.250 in. in length per side. The cell cavity and the hole in the trap flange are 1.250 in. in diameter. The seal shown here was designed for use with a 2.00-in.-o.d. by 0.250-in.-thick ZnSe window (D). The success of this design requires that the window flats be parallel to ±0.002 in. One should order optical flats to this specification or measure them so that those flats not meeting this specification are used for less critical uses. The O-rings used (C and E) are Parker number AN 2-128 (1.487-in.-i.d. and 0.103 in. cross-sectional diam-

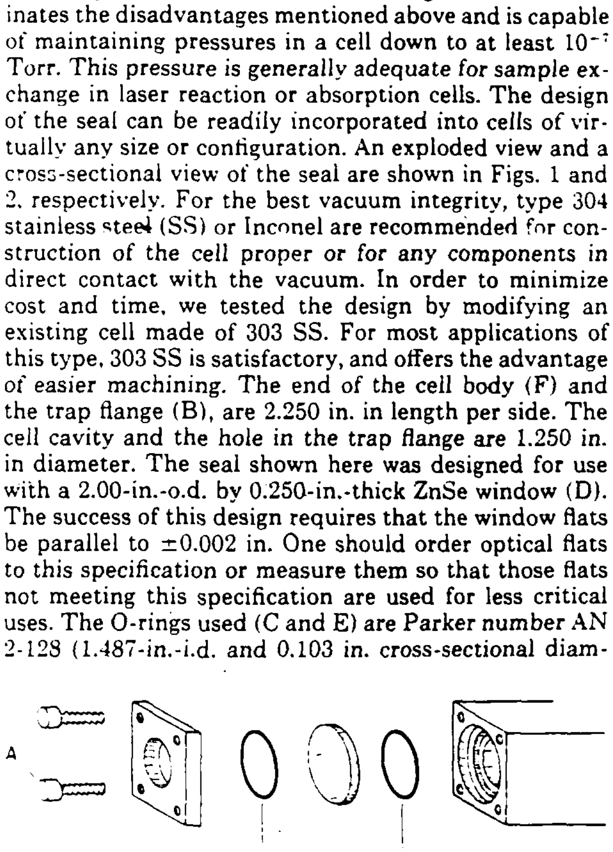

FIG. 1. Exploded view of assembly.

Received 2 July 1987.

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+ Work performed for the U.S. Army under Battelle Columbus Laboratories Contract Number DAAG29-81-D-0100.

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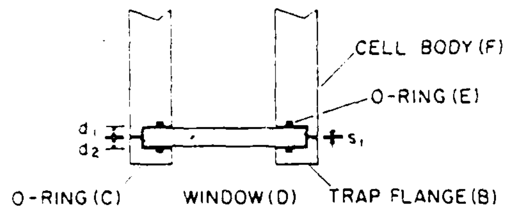

FIG. 2. Cross-sectional view of window.

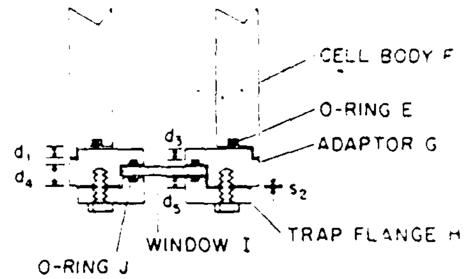

FIG. 3. Cross-sectional view of a small window adaptor.

eter). The O-ring grooves in the cell body and the trap flange are identical in dimensions. The i.d. of each groove is 1.487 in., the depth is 0.080 in., and the width is 0.118 in. The maximum cross-sectional fill of the O-ring groove with this geometry is 88%. With identical O-rings, equal pressure is exerted on opposite sides of the window. The compound chosen for the O-rings is V-747-75, a Viton polymer with a durometer reading of 75. This is an excellent high-vacuum polymer of intermediate hardness, and is well suited to this application. The depth of the seats d_1 for the cell body and d_2 (see Fig. 2) for the trap flange depends on the variation in window thickness among the windows. It is possible to accommodate variation in window thickness by the use of thickness gauges to set the gaps between the window and cell body and also between the window and the trap flange. The existence of the predetermined gaps prevents direct contact between the metal parts and the window. The overstressing of the window, with the increased likelihood of fracture, is thus prevented. In order that variation in the window thickness could be accommodated, the shoulder depths used in the seal are d_1 = 0.125 in. and d_2 = 0.120 in. A 0.002-in. gap between the window and the cell body means that the O-ring has been subjected to a 20% squeeze. The design parameters used in this seal are in accord with the engineering recommendations found in the *Parker O-Ring Handbook*.[7] For designs involving larger or smaller cross-sectional diameters, the handbook should be consulted for proper specifications.

The assembly of a window seal is simple and virtually foolproof. The cell body (F) is placed in an upright position so that the face of the cell is horizontal. O-ring E is placed in the groove of the cell body, and the optical flat (D) is placed in the recessed cell body on the O-ring. O-ring C is placed in the groove of the trap flange (B). Since the i.d. of the O-ring and flange of trap flange (B) are identical in diameter, O-ring C should remain in place as the trap flange is carefully placed on top of the window. Four socket head screws, A (10-32), are used to tighten the trap flange to the predetermined gas s_1 shown in Fig. 2. As mentioned earlier, it is often possible to specify the thickness and tolerances of the window at additional cost. For a fixed window thickness, dimension d_2 may be set so that the trap flange, B, may be bolted in direct contact with the cell body (F) (i.e., s_1 = 0).

To provide for the use of smaller and less expensive windows, we have also designed an adaptor flange system for use with the basic cell. A cross-sectional view of the small window adaptor is shown in Fig. 3. Adaptor flange (G) is also 2.250 in. in length per side. The depth d of the shoulder of the adaptor (G) is 0.124 in., so as to permit metal-to-metal contact (i.e., s_1 = 0) between cell body (F) and adaptor (G). O-ring E provides the high-vacuum seal. The O-ring grooves in adaptor (G) and in the trap flange (H) are 0.612 in. i.d.; the depth of the groove is 0.080 in., and the width is 0.118 in. Parker O-rings (number AN 2-114, compound V-747-75) are used in each of the grooves (O-ring J and its opposite) in contact with the smaller 1-in.-i.d. window I. The shoulder depths d_4 and d_5 are 0.200 in. and 0.125 in., respectively. The thickness of the optical flats used for window I varied between 0.070 in. and 0.100 in. Accordingly, the gap s_2 was calculated and preset with thickness gauges so that a 0.002 in. clearance was maintained between window I and the O-ring faces of flanges G and H.

ACKNOWLEDGMENT

The assistance of the machine shop facilities at the University of Alabama, Huntsville, in the rapid fabrication of the cell modifications is gratefully acknowledged.

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