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AN ALL METAL UHV FLANGE SEAL FOR DISSIMILAR MATERIALS

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Summary

An inexpensive all metal flange seal has been developed for the all aluminum Aladdin RF accelerating cavity that couples up to stainless steel beam transport lines without using aluminum-stainless steel bonded materials. The seal is capable of at least 10^{-9} Torr without detectable leakage and can be baked out at temperatures of at least 300°C. It utilizes commercially available sealing rings and slightly modfied Varian CFF flange components.

Introduction

An all aluminum water cooled RF accelerating cavity that minimizes construction costs while providing adequate cooling has been designed for the Aladdin Accelerator Project. The chamber has stainless steel to aluminum flange connections requiring vacuum sealing of 10^{-9} Torr. These flanges range in tube sizes from 1 inch up to 6 inch and are used for instrumentation, tuning, RF coupling, chamber access, pump connection and beam transport line connection. The seal used is the high pressure expandable seal manufactured by Mott Metallurgical Corporation; Farmington Industrial Park; Farmington, Connecticut 06032; (203) 677-7311. It has proved to be very reliable, inexpensive and heat resistant for all envisioned conditions applied to the Aladdin RF system.

Description

The Mott high pressure expandable seal cross section is sketched in the lower right hand side of the enclosed drawing. It is stamped from 1100-TO aluminum and formed into a chevron shaped cross section. When assembled between two axial faces and two raised inner and outer radial projections as illustrated, the seal extends above the radial projections. To make the seal connection, axial forces are developed by tightening flange bolts that causes the raised seal to deflect radially inward and outward as in a toggle mechanism. Because of very small toggle angles and the sine function as applied to the axial force, extremely high radial forces are generated when the seal contacts the radial projections. Under the axial load, the seal flattens almost completely and maintains high radial forces against the radial projections and cause the 1100-TO aluminum to make intimate contact with the radial surfaces and form the principal seal. Axial metal contact may provide some sealing capability, but is considered unnecessary for proper seal operation. The use of radial sealing surfaces for the principal seal surface provides the advantage of protection against surface damage unlike the standard CFF Knife edge.

The Aladdin flange connections were made by fabricating 6061-T6 aluminum flange inserts similar to CFF stainless steel inserts. However, a radial sealing surface was machined in them towards the outside of the insert for an outer radial seal area. The mating flange was made by facing off the backside of a standard CFF flange with an inner radial sealing surface. The inner seal surface is stainless steel because of the small radial thickness between the seal surface and tube I.D. that will deflect less when large radial forces are developed by the seal.

The Mott seal is supposed to have an axial force equivalent to 2000 pounds per lineal inch outside seal perimeter. Use of the standard CFF bolts and bolt pattern is adequate with proper torque and bolt lubrication. In all CFF compatible seals, only a few are slightly low on axial force only when the bolts are not lubricated and torqued to their maximum rating. Bolt lubrication and proper torquing in all cases develops adequate axial forces.

Utilization

The Aladdin RF cavity used five different Mott seals. Four of them were adapted to CFF flanges and the last was the largest standard size Mott seal applied to an access port with a special bolt circle and blind flange design. Prices of the seals used on the Aladdin RF cavity ranged from $19.50/100 for the smallest to $95.50/100 for the largest size available. Delivery was from stock.

The Mott Corporation will produce custom seals at nominal cost after developing a die for stamping the seal at the customer's expense. These die costs vary from about $1,000 for sizes smaller than 2" diameter and from $2,000-3,500 for the larger sizes. Obviously sizes considerably larger than Mott's present largest size (7 inches) would most likely cost more than the $3,500 shown above.

A chart is provided that lists those sizes of Mott seals most compatible with the CFF flanges, flange and insert dimensions, and bolt torques. It may be noted that in some cases, the standard Mott seals are not always compatible with standard tube sizes and a smaller tube has to be used. In those cases where a standard tube must be used, a custom die would have to be made. The seals shown with the asterisk are those used by PSL on the RF cavity and the double asterisk is the Mott Corporation's largest size and one also used by PSL.

Bolt torques required to develop the full seal axial force recommended by Mott are listed using standard 300 series S.S. fasteners with either dry or lubricated threads. Only the Mini, 212, and 450 flanges with dry threads cannot be fully loaded axially. Lubrication solves this problem.

Testing

The Mott seal was first tested in a 6 inch diameter sample chamber with an 800 CFF modified flange and 6061-T6 rotatable insert in a standard CFF 800 outer flange. Several seals were used with the first two being tested for vacuum tightness using bolt loads as recommended by Mott Corporation. Neither seal had detectable leakage when tested with a CVC 24-110A Helium Mass Spectrometer leak detector with a Veeco SC-4 leak standard at a sensitiviety of 5×10^{-9} Std. cc/sec. The third seal was heat cycled to 150°C twice and to 300°C once. Even though the aluminum would not normally be be baked to 300°C. We wanted to test the seal capability at a full 300°C bakeout. In all cases the seals never had detectable leakage at vacuums of up to 10^{-9} Torr.

The Aladdin RF cavity has had all flange seals leak checked once before final assembly and were reassembled with new seals before final assembly. No attempt has been made to reuse seals because of their low cost and inspection of used seals show them to be almost completely flattened. In no case has there ever been any leakage. Presently, the RF chamber is at about 10^{-9} Torr vacuum.

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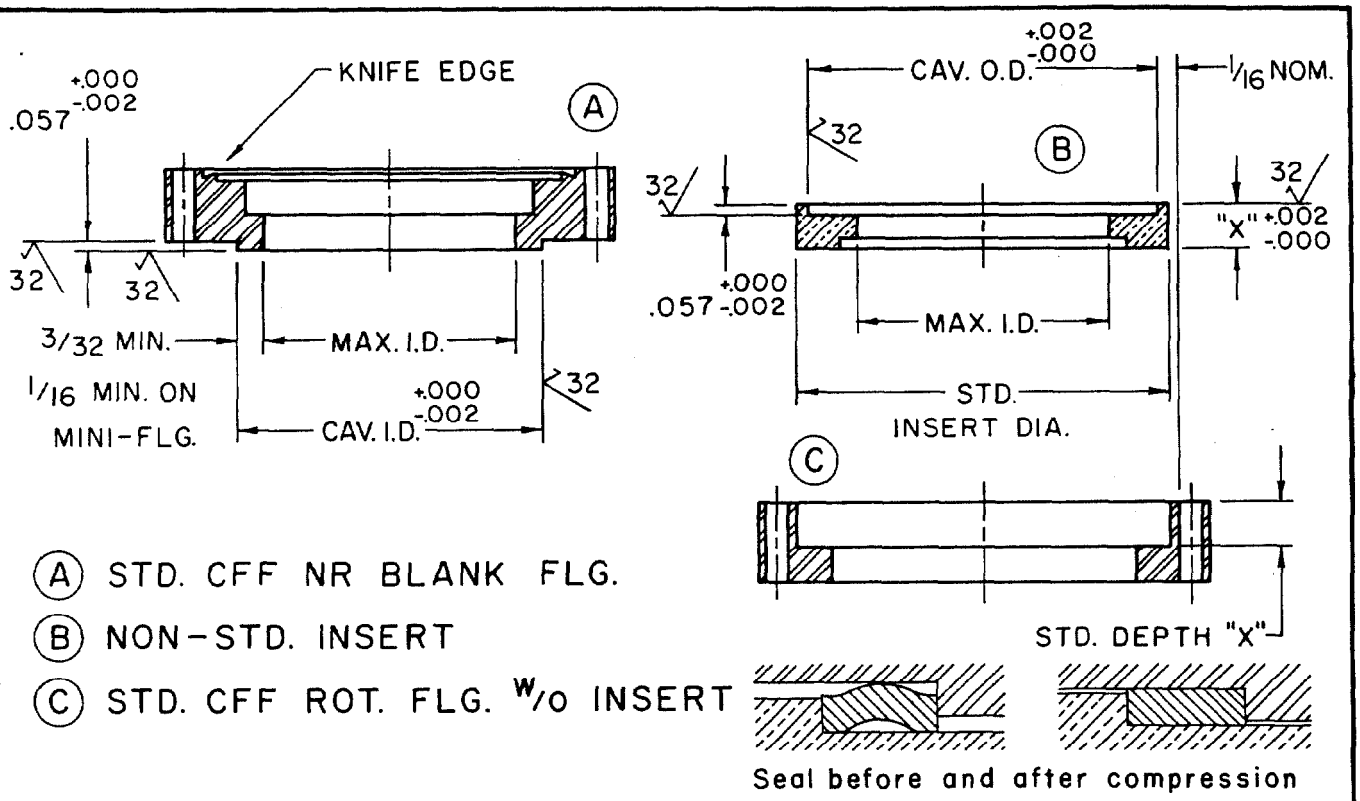

(A) STD. CFF NR BLANK FLG.

(B) NON-STD. INSERT

(C) STD. CFF ROT. FLG. W/O INSERT

* SIZES USED BY P.S.L. ** MAX. AVAILABLE SEAL SIZE

CFF FLANGE	MOTT SEAL			CAVITY		MAX. I.D.	300 S.S. BOLTS	BOLT TORQUE in-lb	
	CAT.Nº	O.D.	I.D.	O.D.	I.D.			DRY THD'S.	LUB'D. THD'S.
MINI-FLG.	10254	.687	.437	.689	.435	.310	8-32	20	18
212-100	10240	1.180	.980	1.182	.978	.791	1/4-28	94	69
275-150*	10255	1.400	1.144	1.402	1.142	.955	1/4-28	74	55
337-200	10203	2.355	1.954	2.357	1.952	1.765	5/16-24	111	83
337-200	10238	2.413	2.053	2.415	2.051	1.864	5/16-24	114	85
450-250	10201	3.188	2.823	3.190	2.821	2.634	5/16-24	142	113
462-300*	10247	3.400	3.055	3.402	3.053	2.866	5/16-24	128	96
462-300	10269	3.440	3.080	3.442	3.078	2.891	5/16-24	130	97
600-400	10272	4.680	4.320	4.682	4.318	4.131	5/16-24	110	83
675-400*	10229	5.310	4.950	5.312	4.948	4.761	5/16-24	111	83
675-500	10245	5.494	5.114	5.496	5.112	4.925	5/16-24	115	86
800-600*	10224	6.250	5.890	6.252	5.888	5.701	5/16-24	118	88
1000-800**	10406	7.010	6.760	7.012	6.758	6.571	5/16-24	110	83