

A BAKABLE ALUMINIUM VACUUM CHAMBER WITH AN ALUMINIUM FLANGE
AND METAL SEAL FOR ULTRAHIGH VACUUM

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A bakable (200°C) aluminium alloy vacuum chamber (6063-T6) with an aluminium alloy (2219-T87) flange and metal seal (Helicoflex-HN: aluminium O-ring) has been constructed. Such components may be used in the construction of the vacuum chamber in proton synchrotron and electron storage ring.

If the stainless steel vacuum chamber were to be replaced by an aluminium chamber the residual radioactivity could be reduced by one or two orders of magnitude 100 hours after machine shut-down. This is illustrated in Fig.1¹⁾ which shows the decay of the residual radioactivity. As a material for vacuum chambers for high intensity electron synchrotrons and electron storage rings aluminium is preferred by virtue of its good thermal conductivity, ease of manufacture of complicated profiles by extrusion low residual radioactivity and low material cost. Since aluminium flanges and metal gaskets were not available commercially a suitable aluminium flange/gasket combination had to be designed and made.

The composition of the aluminium flange and metal seal posed a problem since the surface hardness and the mechanical strength at bakeout temperatures are insufficient in the ordinary aluminium alloys. However a special aluminium alloy 2219-T87²⁾ which was developed for space rocket components has been found to have the necessary mechanical properties. Recently a new type of metal seal - Helicoflex²⁾ - appeared on the market. Basically the Helicoflex is a flexible metal O-ring with an elastic core which supplies the sealing force. The design of an aluminium alloy (2219-T87) flange and pure aluminium Helicoflex O-ring-HN is shown in detail in Fig.2. Such a system can withstand many 200°C bakeouts and repeated opening and closing without leaking. Anodized aluminium alloy (2219-T87) bolts and nuts were used to tighten the flange which was also anodized. The O-ring and its opposite surfaces were not anodized. The thickness of the anodized layer was about 30 μm . The aluminium alloy (6063-T6) vacuum chamber and the alloy flange (2219-T87) were welded by a pulsed TIC process. Distortion after welding was negligible and remachining not necessary.

Test vacuum chamber was 90 mm diameter and 3000 mm long with 150 mm diameter flanges. The cleaning procedure is the following steps: degreasing in paint thinner at room temperature, ethyl-alcohol rinse at room temperature. A photograph of the bench test is shown in Fig. 3. Leak testing after repeated cycling to 200°C was carried out. The leak rate of the flange and metal seal combination was measured with a helium leak detector and found to be $<10^{-11}$ atomsphere cc s⁻¹. The ultimate pressure in the system was $\sim 10^{-10}$ torr. The residual gas pattern by the mass filter at the ultimate pressure is shown in Fig. 4.

The resulting assembly is compatible with ultrahigh vacuum operation and is resistant to hard radiation. This type of vacuum flange and metal seal may be widely used in a proton synchrotron, an electron storage ring and the extracted beam line of a booster synchrotron.

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Reference

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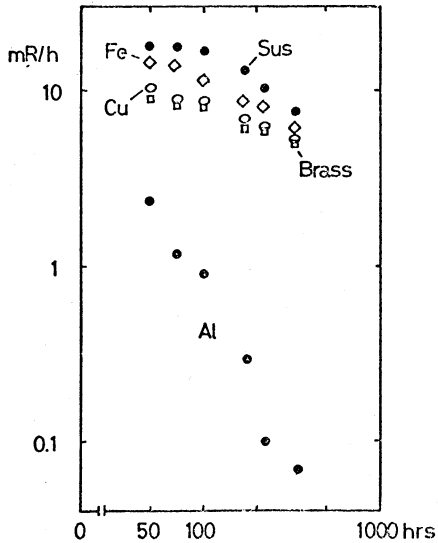


Fig. 1. Decay curve of the residual radioactivity of stainless steel, iron, copper, brass and aluminium bombarded by 0.5 - 8 GeV protons for 400 hrs.

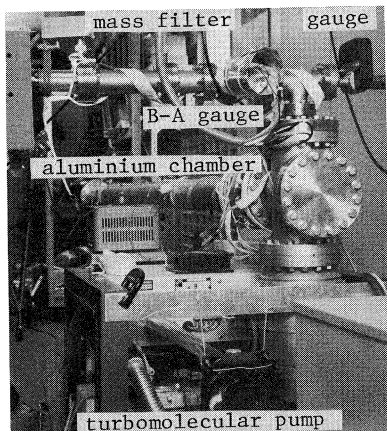


Fig. 3. Bench test of bakable aluminium vacuum chamber with an aluminium flange and metal seal for ultrahigh vacuum.

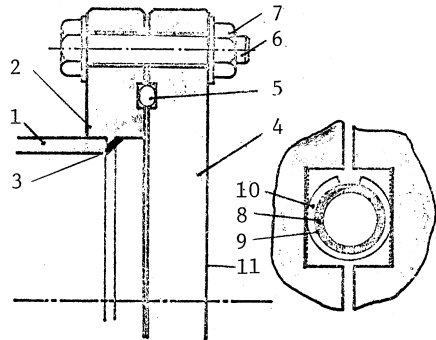


Fig. 2. Aluminium alloy 2219-T87 vacuum flange and pure aluminium Helicoflex O-ring composition. 1. aluminium alloy chamber: 6063-T6. 2. aluminium alloy flange: 2219-T87. 3. welded by pulsed TIG. 4. aluminium alloy flange: 2219-T87. 5. Helicoflex-HN. 6. aluminium alloy bolt: 2219-T87. 7. aluminium alloy nut: 2219-T87. 8. elastic core: Ni base super alloy inconel X750 coil spring. 9. retainer: nickel. 10. pure aluminium: 1050. 11. anodized surface: 30 μ m thickness.

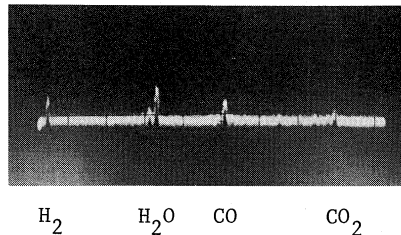


Fig. 4. Residual gas pattern by the mass filter at the ultimate pressure.