Vulcan TAW upgrade – vacuum chamber design

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Introduction

2008 saw the completion of the TAW upgrade project [1] which was to incorporate a second high-intensity beamline alongside existing functionality. Integrated into this project was the need to house new dielectric gratings in a vacuum chamber. This forced a review of the vacuum vessels and required beam transport hardware. The existing compression chamber was too small to fit both the existing gold gratings and new dielectric gratings. It was clear a new compression chamber and an extension to the existing interaction chamber were required to deliver this new beam to target. Floor space was limited ruling out conventional spherical and tubular vacuum chambers. All schematics explored the use of reinforced rectangular chambers.

Compression chamber design

Many schemes were developed before the selection of the dual height compression chamber. This design was to be mostly doors providing good access to the gratings and mirrors whist maintaining enough material to carry the load introduced by the vacuum. Figure 1 shows the chamber during final machining. To keep within budget we were keen that the chambers should be loaded into the building through the existing doors. This was a large driver for the design of the compression chamber affecting not only on the width and height but also the length. For stability, the optics and their mounting hardware was to be mechanically isolated from the chamber structure. The chamber and breadboard legs were to be flexible in length to accommodate unevenness in the floor. Stainless steel 304L was chosen for the chamber due to its out-gassing rate, ductility, ease of welding and stainless properties removing the requirement for plating. Mild steel for the legs and breadboard supports due to its availability, ease of manufacture and good mechanical properties.

The chamber required stiffening tubes inside to reduce the stress to an acceptable level. These are vented to prevent a trapped volume forming. The stiffening is manufactured from standard tube and welded in place. Bellows are utilised to isolate the breadboard legs from the chamber. A detailed assembly is shown in figure 2. The run out on the floor was 7mm over the length of the chamber and to accommodate this shims were fitted between the chamber and the legs.

To allow the chamber doors to be opened and closed easily and quickly dovetail O-ring grooves (see figure 3)

Figure 1. The new compression chamber undergoing final machining.

were cut which trap the O-ring in the groove. This added additional cost in machining and required that O-rings were purchased to the correct size rather than using cord.

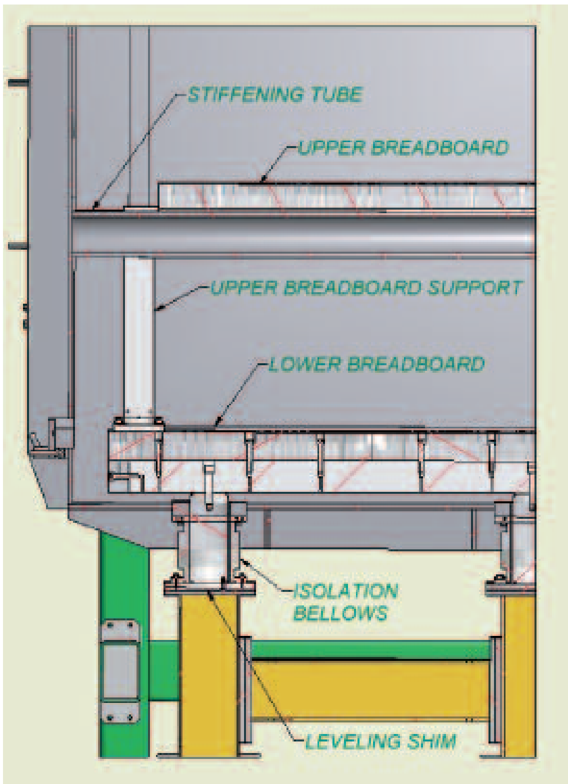

Figure 2. Section through the compression chamber showing a stiffening tube, chamber supports, breadboards and breadboard supports.

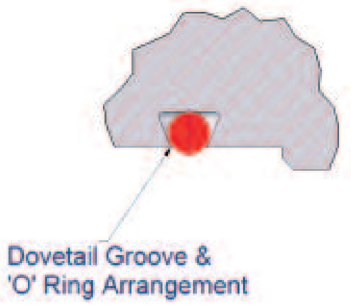

Figure 3. Showing a dovetail O-ring groove.

Beam delivery pipe

In order to accommodate any slight misalignment between the interaction chamber and compression chamber the beam delivery pipe was designed to be flexible in construction. Bellows assemblies are cost prohibitive and we investigated the use of a sliding seal assembly which would be more cost effective. This is shown in figures 4 and 5. The outer flanges have an eccentric pitch of holes to allow for radial misalignment and the sliding seal allows for any angular misalignment and axial loading under vacuum. The sliding seal also permits the assembly to be built and dismantled.

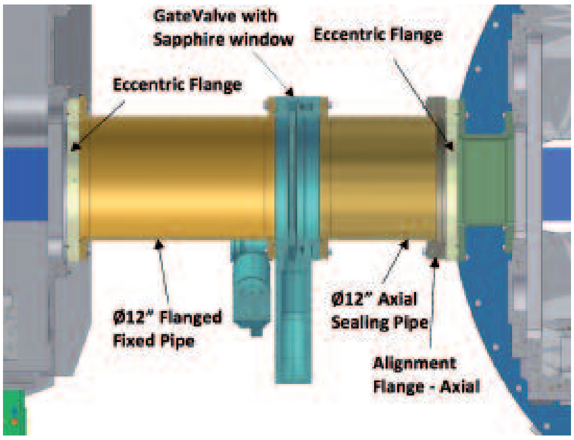

Figure 4. Shows a section through one of the beam pipes connecting the interaction and compression chambers.

Interaction chamber design

In order to get the new beam to target the interaction chamber needed to be extended. The extension was based heavily on the Gemini interaction chamber design with identical standard ports for compatibility with other areas. The use of aluminium was not necessary for radiation, but the thicker panels offered more flexibility to recess the top and bolt on railings.

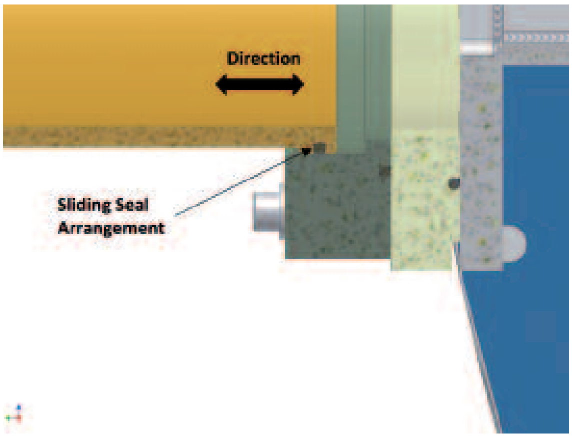

Figure 5. Shows a close up of the sliding seal.

The existing interaction chamber ring section was kept to interface with cluster hardware. Large doors were designed in to attain access to the optics and diagnostics. A single height breadboard was designed and again is isolated from the chamber with bellows. Access to the top of the chamber for diagnostics above the target was identified as a growing trend. The flanges on the top of the chamber have been recessed to ensure a flat surface to walk on with safety rails and multiple step ladder access points. This is all shown in Figure 6.

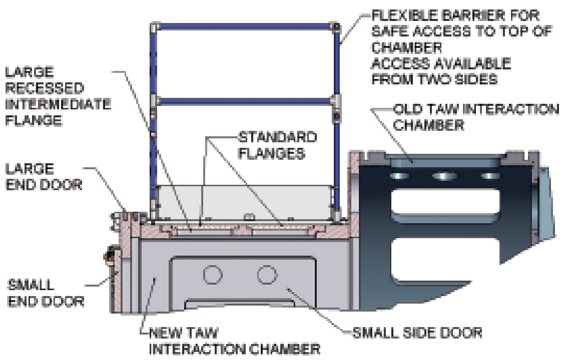

Figure 6. Section through the extended interaction chamber.

References

1. C. Hernandez-Gomez, CLF Annual Report, 260-262, (2007-2008).