P 3 FITTING A HEMISPHERICAL GLASS WINDOW ON A METAL SUPPORT

Principle

Hemispherical windows are to be fixed onto their metallic supports in such a way as to be capable of withstanding temperature variations between 300 K and 25 K.

The system also has to support a test pressure of 15 kg/cm² acting against the convex side of the hemisphere and of 1.5 kg/cm² in the opposite direction. The assembly must remain tight in both situations.

Use in BEBC

The Big European Bubble chamber (BEBC) has five sets of hemispherical windows mounted on their metal supports. Each set consists of three hemispherical windows which should be concentric at the temperature of liquid hydrogen (250 K). Measurements have shown eccentricity of 50 μm. The three windows are thermally isolated by two vacuum systems (10⁻⁷ T). The largest window is completely immersed in liquid hydrogen, has a diameter of 385 mm and a thickness of 35 mm.

The normal working conditions of the bubble chamber are as follows:
- Temperature T = 26 K
- Static pressure P = 5 Kg/cm²
- Magnetic field at the windows B = 2.7 Tesla
- Maximum acceleration caused by the expansion system at the window supports γ = 8 g.

Construction

Only the large window is made of glass (BK7 Special, from Schott), which has a particularly uniform refractive index of the order of a few time 10⁻⁶, while the small safety windows are of Herasil top quality quartz.

The metal was selected so as to produce the smallest possible difference in contraction between the support and the window during the cooling.

Measurements made at CERN at liquid nitrogen temperature showed relative differences in length δL of 0.5 to 0.6 o/oo. Feni 42 was chosen for the BK7 window and feni 36 for the quartz windows. These metals consist of invar: they are feni 42 and feni 36 containing respectively 42% and 36% nickel.
After the metal supports and the windows have been manufactured to very strict tolerances (less than 0.01), they are lapped together. The outer surface of each window ends in a cylinder 20 mm high, fitting into a thin flange, 0.5 mm thick, in the support. The clearance between the flange and the cylinder is between 0.20 and 0.30 mm and is filled with the "glue" (Devcon F2 + FLEX) providing the seal.

The three windows are then assembled, centred with microscope, and finally pinned.

This was the first time that assembly of optical glass manufactured with metal had been capable of satisfying the tests described.

Many manufacturing problems were raised by the choice of materials: the construction of the quartz windows required many consultations with specialists (diameter of this size never made; risk of cracks and bubbles in such big pieces).

The welding on the thicks invar supports required a great deal of investigation (electron beam welding, welding with a filler metal, etc.) before a satisfactory technique could be used by CERN workshops.

For the final design now used, two years of work had to be done before the best glue and its thickness were found and, above all, before a rigid but elastic system (flange machined in the solid metal, clearance beneath the base of the window, lapping-in of the support and the window) could be worked out.

Set of fish-eyes