Glass Bead Testing using the gas mixture
Ar 70% + CO2 30% in a small test fixture
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The Duke University ATLAS TRT group recently reported that the glass bead wire joints were eroded away by the ionization products produced in the straw drift tubes using a xenon-based gas containing CF4. This observation was previously confirmed at IU in an argon based gas. The Duke group also tested the glass beads in a xenon-based gas containing CO2 but no CF4. They reported some cloudiness of the glass bead after irradiation of the test assembly (see figure 1).

Figure 1 - Results from Duke Test

This is a concern because any damage to the glass at the level of irradiation achieved in these tests could indicate an unacceptable amount of damage in the full detector at LHC.

The Indiana University ATLAS TRT group again sought to confirm these findings in the same small test fixture that had been used for wire aging studies in 1999. A diagram of this fixture is shown here.
There were nine straws about 13 cm long in this test fixture. Each straw had a twister wire support at each end. Five of the nine straws (the ones on the “left” side and the middle) were strung with a standard wire including a standard glass bead wire joint positioned 1 cm from the twister at one end. The remaining straws were not strung.

The active volume was sealed up with Ultem sheets and epoxy. All active gas lines and fittings were made of stainless steel. The space around the straws was also sealed up and flushed with dry CO₂. The plumbing here was done in copper with brass fittings.

The gas in the active volume was 70% Ar 30% CO₂. This was mixed for us by Air Products Corp. It was flushed through the straws at a rate of 1.8 cc/min or 0.2 cc/min in each straw. This corresponds to a linear flow rate in the straw of 1.6 cm/min. This flow rate can be compared with the nominal flow rate expected in a full-length (1.4 m) straw. Using the criterion of 1 volume change per hour in the straw (4 mm diameter), the nominal flow is 0.3 cc/min. The gas flow in this test was therefore 2/3 nominal. We didn’t have a moisture analyzer for this test, but we used our oxygen meter after the test was over. The CO₂ from the test fixture had oxygen at a level of 270 parts per million. The active gas at 6 times the flow rate was 60 parts per million. The oxygen meter doesn’t work for low flow. This check helps to confirm the absence of significant leaks.

The radiation from the two Sr⁹⁰ sources was centered on the “left” straws 8 cm from the glass bead and 5 cm from the glass bead. It took 3 to 4 minutes for the irradiated gas to move from the radiation sources to the glass bead.

The voltage was set at 1526 V (gain about $8 \times 10^4$) to generate a large amount of ionization current. This is considerably more than the voltage for the nominal gain of $2 \times 10^4$ (which would be 1400 V). There may be an enhancement of active radicals at larger voltages, but for this test we wanted to see an effect in a short period of time.

The test was run between 10 Nov 2001 and 13 Nov 2001, a time interval of 70 hrs (0.25×10⁶ seconds). During that time there was no interruption of the voltage. The current on wires 2-left and 3-left was 3.9 µa leading to a total charge of 1 C; C-mid and 1-left had 3.4 µa for 0.8 C and C-left had 2.8 µa for 0.7 C. The length of the irradiated section of wire was about 7 cm.
Here are pictures of the wire beads that were removed from the test fixture.

Results from Indiana University - 11/13/01

Straw C-left

Straw 1-left

Straw 2-left

Straw 3-left

Note: the break occurred while positioning the beak for the photograph and has not bearing on the effects of the test.

Conclusions

No visible discoloration of the glass bead in any of the test samples.