

The Expected Moisture Level in the Barrel Module Straw Tubes

**Seog Oh, Bill Ebenstein
Department of Physics
Duke University, Durham, NC**

Introduction

The moisture content inside straw tubes plays an important role in the sense wire integrity. It was found that with the moisture content well above 1000 ppm, the gold plating on the sense wire could deteriorate. Recently, it was also found CF_4 radicals combined with water etches away the glass wire-joints in the barrel module. In this paper, we report on the expected moisture level in the barrel module.

Because straws are made of kapton and moisture permeates kapton quite well, we expect that the moisture level inside the straw tubes is similar to the moisture level in the purging volume because the gas exchange rate inside straw tubes is slow (less than 1 exchange/hour).

The moisture level in the purging volume for the barrel module is dictated by the water tightness of the shell. Because the carbon fibers used to construct the shell have resin through which moisture cannot permeate easily, the moisture level in the purging volume is expected to be low.

Measurements

For the measurement, module type 2.02 was used. The construction holes in the shell were plugged up and the leak rate was measured. Using the pressure drop method, the leak rate of the purging volume was measured to be better than 10 mb/bar/min. Since this leak rate was good enough for our moisture level measurement, no further attempt was made to reduce the leak rate.

The purging gas used in the measurement was N_2 . The purging volume of the type II is about 24 liters. Initially the flow rate was set at about two volume-exchange/hour. The moisture content in the purging gas at the input to the module was measured to be 60 ppm. The relative humidity in the room varied from 25% to 35% and temperature varied from 21 to 23 centigrade during the measurement.

A moisture sensor was connected to the output gas line from the shell and the value was recorded periodically, and shown in Figure 1. The y-axis is the moisture level in ppm and

the x-axis is the time in days. As seen in the plot, after an initial ‘fast’ drop, the decrease slows.

After a week of gas flow, the moisture level dropped to about 400 ppm. At this time, the flow rate was changed to one volume exchange/hour (the morning of Feb 6). As shown in the plot, the moisture level jumped to about 700 ppm.

After two days of running with one volume-exchange/hour, the flow rate was changed to two volume-exchange/hour. The moisture level dropped to about 250 ppm after a few days. We note that the measured moisture levels include ~60 ppm moisture in the input gas.

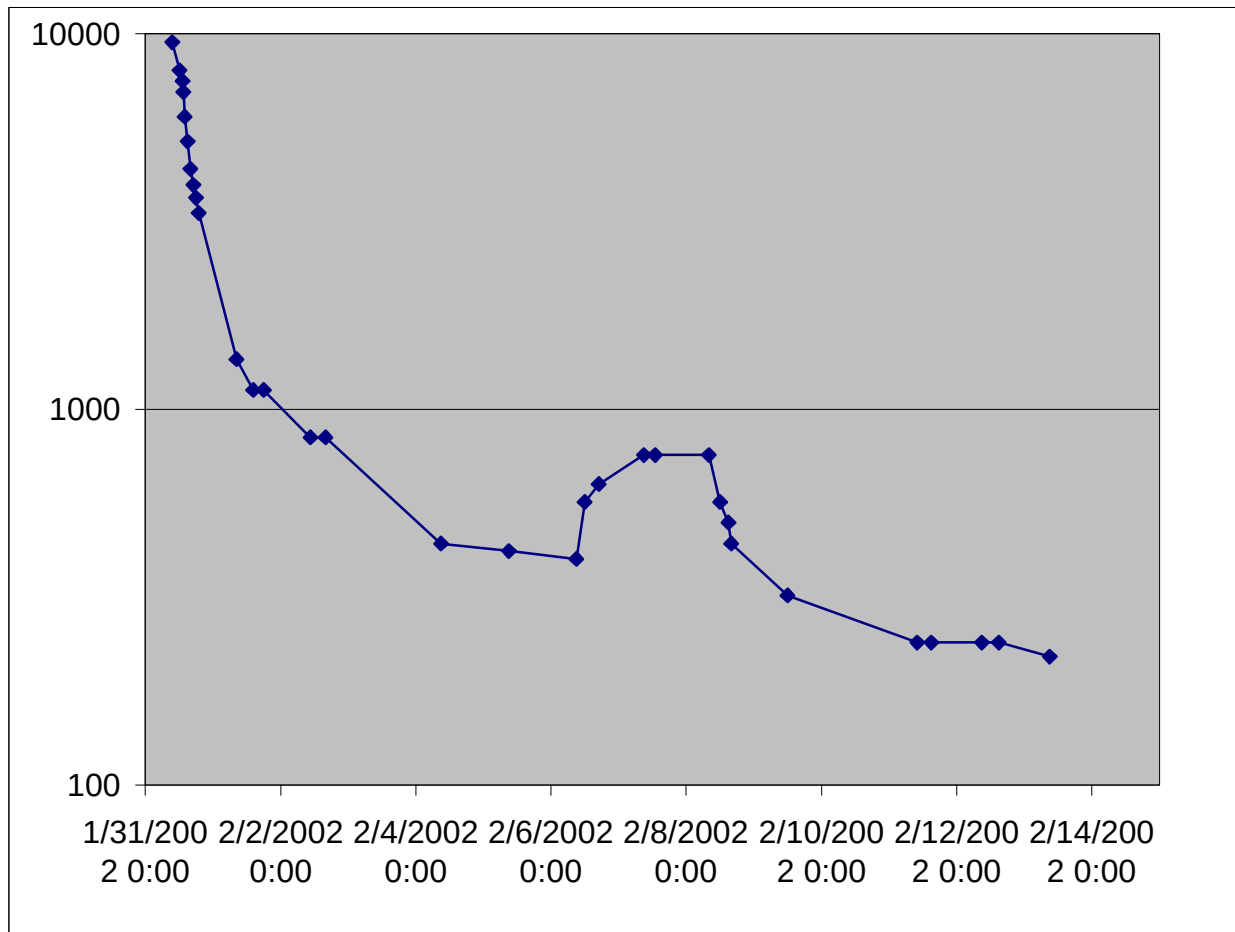


Figure 1. The moisture level (in ppm) inside the purging volume as a function of time. The x-axis is from Jan 31 to Feb 13. The sudden jump (drop) corresponds to the change of the exchange rate from two (one) volume/hour to one (two) volume/hour.

Summary

We measured the expected moisture level inside a type II barrel module (type 2.02). With two volume-exchange/hour, the moisture level in the purging volume is about 180 ppm (after the input moisture level is subtracted out). Changing the flow rate to one volume-exchange/hour increases the moisture level by ~ 300 ppm. From these numbers, we estimate that the water permeation through the type 2 shell is about 800 ppm/hour and we obtain the following table under the assumption that the input gas has no moisture content.

Purging Gas Exchange Rate (volume/hour)	Moisture Level (ppm)
0.5	~ 800
1.0	~ 400
2.0	~ 200
3.0	~ 150

Another observation from the measurement is that the radiator sheets inside modules contain appreciable amount of moisture and it takes about a week to get the moisture level down to a few hundred ppm.

One dependence we have not measured is the moisture level as a function of humidity and temperature. To measure the humidity and temperature dependence, it may be necessary to construct a gas tight box with a humidity and temperature control. However the environmental condition during our measurement would not be very different from the one expected during the ATLAS experiment. The relative humidity in the room during the data taking period varied from 25% to 35 % and temperature was uniform within a couple of degrees around 22 C. During the LHC experiment, the temperature of the shells cooled by the cooling tubes should be around 20 C and the humidity around the modules should be similar to the ambient humidity in the detector cavern.