Quality Assurance Tests on Bakelite Produced for the Prototype D RPCs of the PHENIX Forward Upgrade

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Abstract

The PHENIX Forward Upgrade Resistive Plate Chambers (RPCs) are being designed in such a way that they will be nearly identical in construction to the Compact Muon Solenoid (CMS) endcap RPCs. In an effort to produce similar deterctors PHENIX hopes to follow a production route similar to that of CMS. We needed to determine, however, if bakelite produced by the same production facility can still be produced to the same specifications. We present here the results of testing on bakelite produced for the Prototype D RPCs of the PHENIX Forward Upgrade project.

Introduction

The testing of bakelite produced for the PHENIX Prototype D RPCs was done in two stages. The first stage was a destructive set of tests wherein three large sheets of bakelite were cut into $30cm \times 30cm$ squares in order to characterize the resistivity across the entire sheet and thoroughly test the uniformity of the resistivity. After the results were found to be consistent with previous CMS measurements a less thorough set of testing was done to characterize the remaining sheets produced for the prototype.

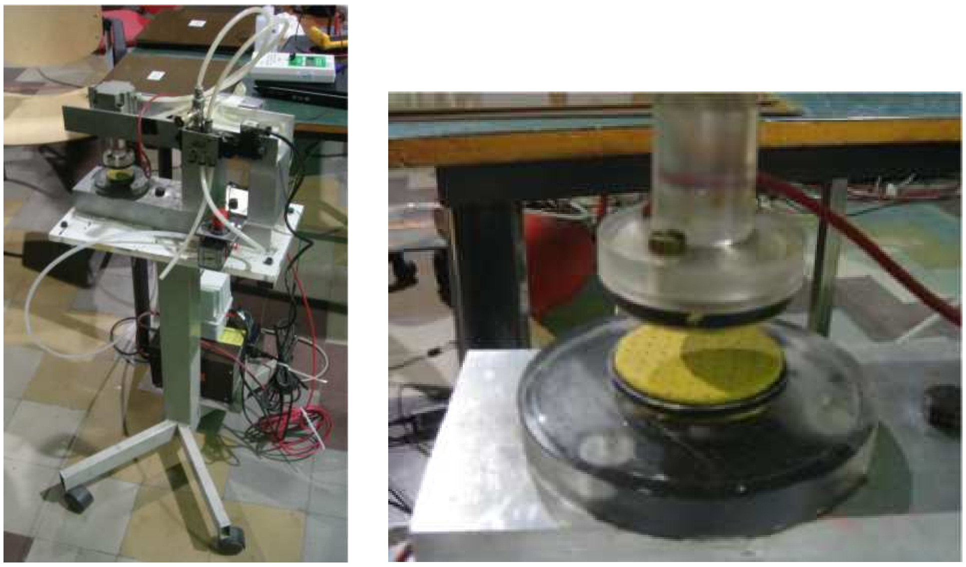

Figure 1: Device used for majority of resistivity measurements. On the right is simply a closeup on the pads which clamped to the surface.

Bakelite Specifications

The baseline used for determining whether or not quality bakelite had been produced was the CMS specifications as follows:

$$1 \cdot 10^{10}\Omega cm < \rho_{20C} < 6 \cdot 10^{10}\Omega cm \tag{1}$$

$$\frac{\sigma}{\rho_{Average}} < 0.5 \tag{2}$$

$$thickness < 2mm \pm 0.1mm \tag{3}$$

$$R_a < 0.2\mu m \tag{4}$$

where σ is the standard deviation of the measurements made on a given sheet of bakelite, R_a is the average surface roughness, and ρ_{20C} is the resistivity corrected to the resistivity of bakelite at 20C using the temperature correction

$$\frac{\rho}{\rho_{20C}} = e^{\frac{T-20C}{7.8C}} \tag{5}$$

obtained by CMS at 30% humidity. While the conditions (1) and (2) were measured thoroughly, conditions (3) and (4) were only spot checked as they were for CMS production.

Resistivity measurements were made using the device pictured in Figure 1. Wet pads are clamped onto a piece of bakelite using a compressed air piston

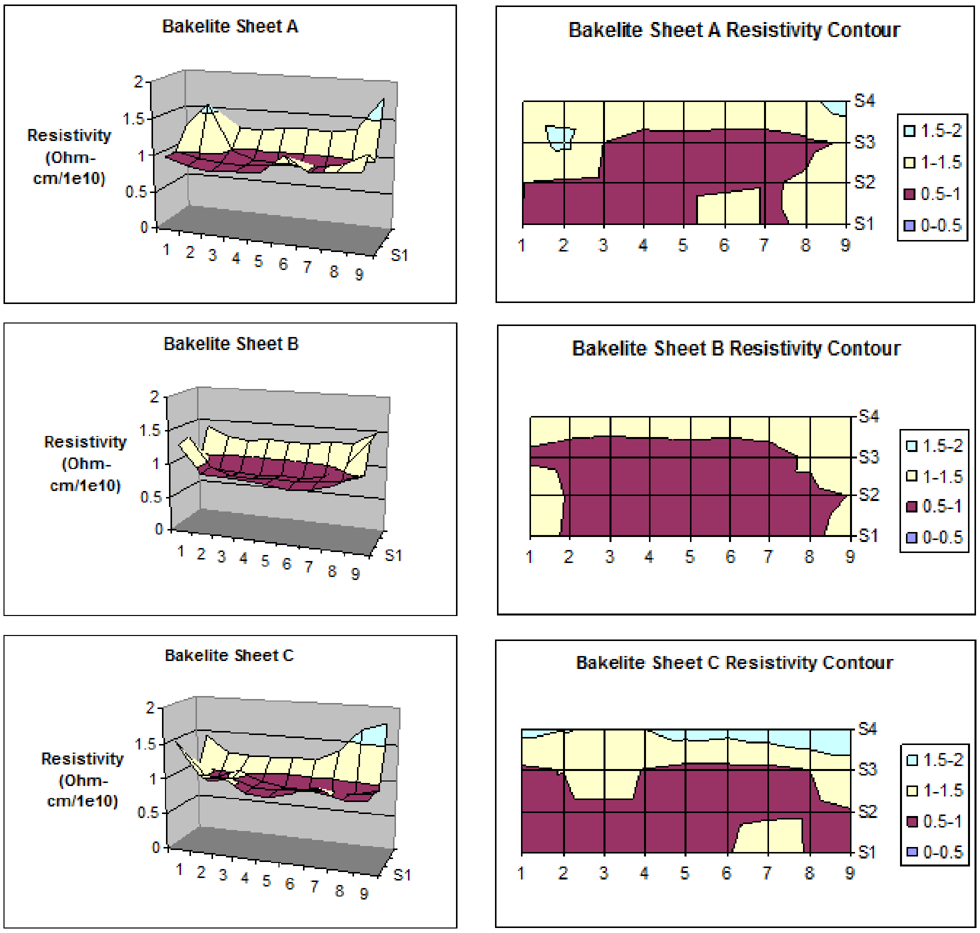

Figure 2: Surface plots and Contours of Resistivity from destructive testing at Pavia University.

Sheet	*Average Resistivity* (10^{10} Ω *cm)*	$\frac{\sigma}{Average}$
A	1.08	0.220
B	1.022	0.220
C	1.08	0.221

Table 1: Average Resistivities and Standard Deviation over average from destructive testing at Pavia University.

and a high voltage is applied. The voltage across a resistor in series with the pads is then used to calculate the resistivity of the bakelite. Resistivity measurements were found to be repeatable to within approximately 10% accuracy.

Thorough Destructive Testing of Bakelite

The three sheets tested at the University of Pavia were taken from three different places in the oven of one production batch. Sheet C was on the bottom, B in the middle, and A on top. Four measurements of the resistivity were made of each $30cm \times 30cm$ sheet. Averages of these resistivities were then plotted across the sheet giving us the resistivity surfaces and contours plotted in Figure 2. Average resistivities for the entire sheets as well as the standard deviations over averages are listed in Table 1. The resistivities of these plates were a bit low but still within CMS specifications. The standard deviation over average was well within the specifications.

Characterization of Sheets for the Prototype

As we were satisfied with the results of the destructive testing we proceeded to test the remaining 51 sheets at the production facility. Sheets were tested in the opposite order of production (i.e. the last sheets produced were the first sheets tested). Six measurements were made on each sheet, three on each long side. Results of average resistivities and standard deviations over averages are plotted in Figure 3 while histograms of the results are plotted in Figure 4. One entire batch (6 sheets) of Bakelite was 2.2mm thick and noticeably different in color. We were informed that the manufacturers knew the cause of the problem and that it had something to do with the parameters of the press. While a couple of quick tests indicated that this bakelite may have still met resistivity specifications we decided to discard the entire batch.

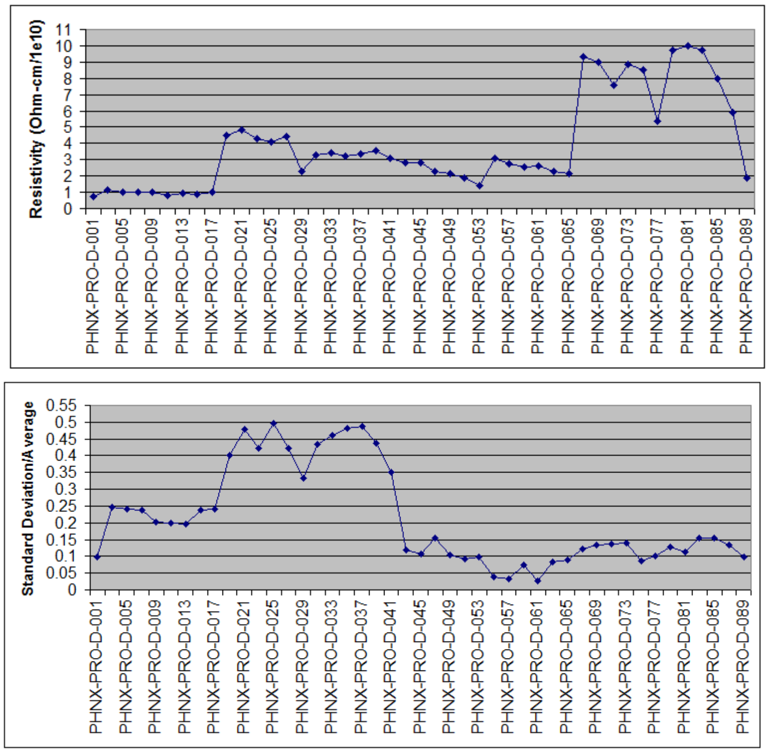

Figure 3: Resistivity and standard deviation over average for sheets tested at the production facility. Sheets were tested from left to right while production order is from right to left.

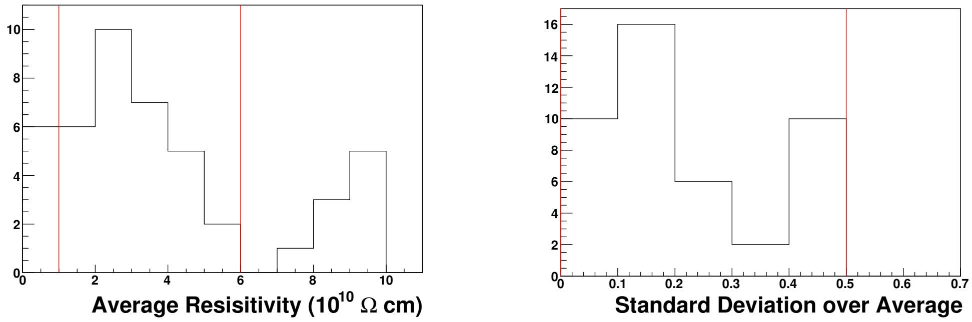

Figure 4: Histograms of the average resistivity (left) and standard deviations over average resistivites (right) of sheets tested at the production facility. Bins inside of the reds lines indicate sheets acceptable by the CMS specifications.

Overall 54 sheets were produced for the PHENIX prototype D RPCs of which 33 passed CMS specifications (3 of these were cut up for our destructive testing). Of the sheets that failed, 6 were produced to the wrong thickness, 6 had resistivities which were too low, and 9 had resistivities which were too high. No sheets failed the uniformity specification, but 10 sheets had standard deviations over averages greater than 0.4 and were very close to failure. These 10 sheets, however, were well within the range of acceptable average resistivities.

Since 40 sheets were needed for the prototype all sheets within CMS specs were accepted (excluding, of course, those which had been destructively tested) as well as several with resistivities that were too high.

Acknowledgements

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