

Energy Storage and Dissipation Notes
Note 4

22 July 66

Measurement of the Conductivity
of Copper Sulphate Solutions

by

J. C. Martin

Atomic Weapons Research Establishment

First Printed as SSWA/JCM/667/67

Much of the confusion in copper sulphate solution resistivity measurement derives, it seems to me, from surface insulating films and/or electrolytic action at the electrodes. The behaviour of the Wayne Kerr bridge is particularly revealing in this respect, since if a measurement of resistivity is made with it of a liquid resistor which has been made up some time, a large value of the capacity is also read, while at the same time the resistance comes out too high. This is interpreted as the effect of partial capacity in series with a resistor. If a current of a few tens of milliamps per cm of electrode is passed for ten or twenty seconds, new electrode surfaces are formed in part and the resistance falls and the capacity reading in the bridge becomes very small, one or two units on the dial. In one case this treatment caused black flakes to come off the electrodes and float about in the solution. In other cases copper is presumably laid down on the resistive film while sulphate ions are free to attack the film at the other electrode. Avo readings also become lower and agree with the bridge measurement, although care must be taken that a small cell voltage (because of the different ion concentrations at the electrodes) does not strongly influence the Avo's readings. This can be done by measuring the resistance both ways round. The act of reversing the clearing voltage a few times does not seem to interfere with clearing the insulating film and does not leave any significant cell voltage afterwards. Another way round a residual voltage is to short out the resistor for a few tens of seconds.

If a battery for clearing the electrodes is not to hand, the Avo can be used to perform this function mostly. As such it is switched to the $\div 100$ range and then left until the reading finishes falling. It is this reading (or lower) which is the correct one. Even when the reading has to be taken on the $\times 1$ range, a caking on the lower range for a minute will reduce the reading obtained and bring it closer to the truth.

With a cell with fairly old and used electrodes, the reading obtained on the $\times 1$ range of the Avo can be three or four times as high as the real one, and the reading on the lower range can come close to the proper value. After passing a reasonable current from a 9 volt battery the Avo reading fell further and came into alignment with that given by the Wayne Kerr, which showed only a very small value of capacity during the measurement. These values were compared with those obtained by using a pulsed bridge technique which put 600 volts across the resistor and agreement got to within $\pm 2\%$ between the three values. The mean value of these determinations was also within this error of the resistivity calculated for the solution from standard tables from the concentration of copper sulphate.

A check was made on the resistivity test sometimes employed, using the Avo metal ore leads. These are held close together and put in the solution. Once again the more

consistent values are obtained on the lowest range of the Avo that can be used. The multiplying factor needed to get the resistivity of the solution is about 5 for the values obtained with the $\div 100$ and $3 \frac{1}{2}$ for the readings on the $\times 1$ range. However, the error on these measurements can be quite large (up to $\pm 20\%$) and may well depend on the condition of the ore clips. However it is a quick way of obtaining a rough measurement of an unknown solution. Since there is a test cell now available, it should be easy to make a more accurate measurement quickly and easily.

As an additional aid to obtain solutions of known resistivity, a standard solution has been made and a dilution graph attached to it. This gives the volume of deionized water to be added to unit volume of standard solution to give any required resistivity. The solution chosen, 250 grammes of hydrated copper sulphate crystals with 750 grammes of water, is rather concentrated and if allowed to cool well below 17°C ., some of the sulphate may crystallise out. That this has not happened should be checked before the stock solution is used. In the case of very weak solutions, the dilution should be done in two or three stages and the quality of the deionized water also checked to make sure that it will not reduce the resistance required by adding a significant quantity of other ions. The accuracy obtainable is probably of the order of 3 or 4% when using this dilution technique.

SOLUTION 250 GRAMS OF $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ DISSOLVED IN 750 gm H_2O
 RESISTIVITY 24 OHM/cm $\frac{\delta\sigma}{\sigma} = -0.022 (T-18)$ T temp °C

