Measurement of Temperature Dependence of Electrical Insulation Resistance of Epoxy Grout and Two Industrial Laminates for Busbar Insulation

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Abstract

Insulation materials are an important element in pot and potline design and safety. They must provide high insulation resistance between different potentials in a cell or between cells and ground as well as sufficient mechanical strength at elevated temperatures. In EGA, epoxy grout has been used extensively for busbar, potshell and potroom floor supports for insulation from ground. The manufacturer specifications usually do not include electrical properties because they depend on particular mixture of ingredients which could change with time and most epoxy grout applications are not intended for electrical environment. Consequently, it is up to the users to measure electrical resistance otherwise they may risk unwanted failures, particularly if high temperatures are involved. At EGA, a laboratory workbench for the measurements of insulation resistance has been set up according to the ASTM D257 Standard. Electrically conductive paint was chosen for contact surfaces, configured for volume resistivity measurements. Two types of epoxy grouts were measured at room and elevated temperatures up to 240 °C. The measured insulation resistance of epoxy grouts decreases exponentially with temperature which agrees with theory. The exponential coefficients were determined from the measurements. Similar measurements were also made for two rigid industrial laminates used for busbar insulation and similar behavior with temperature was observed.

The measurements of epoxy grouts were made at EGA, whereas the measurements of the industrial laminates were made at ISOVOLTA laboratory as this laboratory has a convection heating furnace according to IEC 60216-4-1 Standard for measurement of thermal endurance of insulation materials. Insulation resistance of measured epoxy grouts was sufficient for busbar supports up to approximately 200 °C and of rigid busbar laminates up to 240 °C.

Keywords: Electrical insulation resistance of epoxy grout, electrical insulation resistance of industrial laminates, ASTM D257 Standard, electrically conductive paint, thermal endurance of insulation materials.

1. Introduction

1.1. General

Aluminium electrolysis potlines and individual pots are characterized by areas of different electrical potential, which can be as high as potline voltage between potline busbars and ground [1]. In a pot the anodes and anode superstructure are typically on 4 – 4.5 V higher potential than the cathodes. However, when the pot is on anode effect, this difference could be as high as 100 V depending on plant design. To separate these electrical potentials and to separate pots from ground various insulation materials are used. Figure 1 shows a pot with the insulation locations indicated.

This work investigates and reports the results for the electrical insulation resistance of two epoxy grouts used at EGA for the insulation of the potlines to ground and two industrial laminates which are used for insulation between busbars of two adjacent pots.

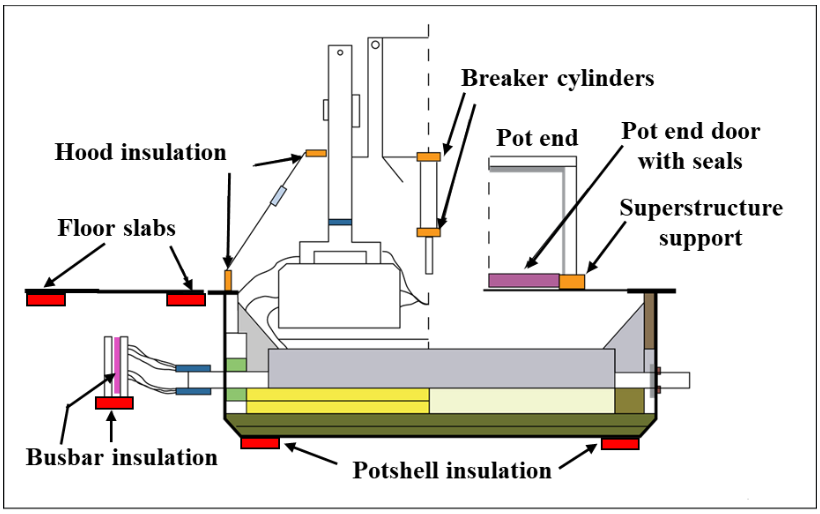

Figure 1. Location of insulators between pot superstructure and cathode as well as between the potline and ground. Investigated in this paper are epoxy grout (red) and industrial laminates (pink) – see more detail in Figure 3.

1.2. Insulation Resistance

Electrical insulation resistance is the important parameter, which is only quoted at room temperature (industrial laminates) or not at all (epoxy grout). Busbars and potshells are at high temperature, typically below 200 °C, but sometimes higher. Over time, these insulation materials can fail due to high temperatures and this aggregates because of ever increasing potline amperage. The failure can be mechanical and/or electrical. Figure 2 shows such a case [2]. Busbar insulation materials may start to degrade at 200 °C but at 250 °C many of them would have catastrophic failure [2].

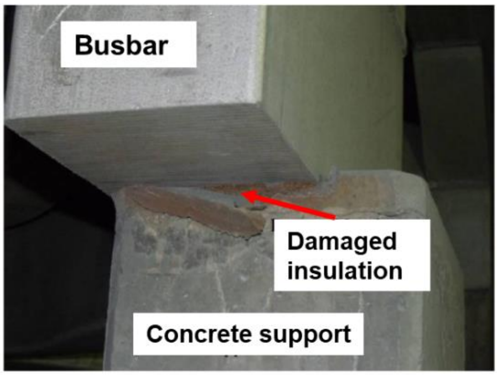

Figure 2. Busbar insulation on concrete supports crushed due to amperage increase [2].

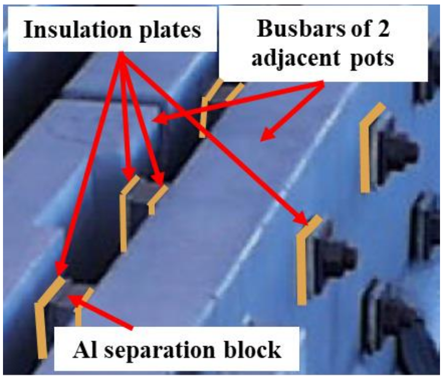

Figure 3. Industrial laminates: insulation plates between adjacent pot busbars, typically 5 – 6 mm thick.

1.3. Thermal Properties

Thermal characteristics of insulation materials may be different for each property, such as mechanical strength, insulation resistance and dielectric strength. Compressive strength and

In this work long term thermal endurance of the measured materials was not determined. However, long term usage of these materials in smelters has proven that they have not failed during service for many years and thus are appropriate for busbar insulation.

At EGA, we developed a workbench and a technique for testing insulation resistance of insulation materials at elevated temperatures according to international standards. Any material that has no insulation resistance specification should be tested before use in potrooms. For temperature measurements we recommend that convective ovens should be used for heating the samples according to IEC 60216-4-1.

6. Acknowledgement

We thank Dr. Bogdan Rares Enache from ISOVOLTA Bucarest Laboratory for the measurements of the two industrial laminates ISOVAL® R-AL and ISOVAL® 220.

7. Disclaimer

Electrical insulation is not the primary purpose and application of epoxy grouts. Insulation resistance of epoxy grouts is not a material specification parameter. Therefore, there is no guarantee that the values measured in the present samples will be kept the same in the future or that the chemical composition of these epoxy grouts will not be changed in such a way to affect the insulation resistance negatively. On the other hand, industrial laminates are better defined materials and are certainly more consistent. Nevertheless, the results reported here should be taken only as typical behaviour with temperature and should not be transferred to other materials or manufacturers. Therefore, the measurements in this paper are not a guarantee for any of the materials measured that the insulation resistance will remain the same in the future. This paper is also not a formal approval for any of the materials measured to be used in a specific project. It is recommended that the same measurement should be repeated before these materials are used for any major pot technology implementation.

8. References

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