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ANALYTICAL QUALITY CONTROL IN THE PRODUCTION OF NUCLEAR GRADE ZIRCONIUM AND ITS ALLOYS(*)

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The chief application of zirconium metal and zircaloys is in nuclear reactor engineering as cladding material for the fuel elements and as structural material in the construction of reactor cores. The selection is based on considerations of low neutron absorption cross section, fabricability, corrosion resistance and mechanical strength at elevated temperatures. These properties are however sensitive to impurity levels and alloying compositions. For example, for neutron economy the hafnium and boron contents should be within 200 ppm and 0.5 ppm respectively; for corrosion resistance the aluminium, carbon and nitrogen tolerances are respectively only 75 ppm, 500 ppm and 50 ppm; and for ease of fabrication the maximum permissible oxygen content is 1500 ppm. In the large scale production of zirconium sponge and zircaloy ingots, it becomes therefore essential to have a strict control of impurity levels in the successive stages of the batchwise production, in order to ensure consistency of quality and performance in the finished product.

This paper discusses the importance of analytical quality control in the various stages of tonnage-conversion of Indian zircon successively into pure zirconium oxide, zirconium sponge metal, zircaloy ingots and tube products, to meet stringent nuclear specifications. A general scheme of sampling is presented for the different stages. Methods of analysis of various impurities in zirconium intermediates and zirconium metal and alloying elements in zircaloy are discussed.

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The authors arrive at the conclusion that the production of zircaloy components for nuclear applications has to be supported by a large-scale analytical control programme, keeping a strict watch on quality from batch to batch. As the ultimate performance of the various zircaloy components will be dictated by the purity and homogeneity of the alloy ingots and as many of the zircaloy components in the core of the reactor have to last for the lifetime of the reactor, such a close quality control is fully justified to ensure reliability in service. A rough estimate on the cost figures shows that analytical quality control alone would contribute about 4% to the cost of the finished zircaloy products.

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