Creep of Zirconium Alloys in Nuclear Reactors

Franklin/Lucas/Bement

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CREEP OF ZIRCONIUM ALLOYS IN NUCLEAR REACTORS

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Foreword

The Metal Properties Council, as part of its continuing role of collecting, analyzing, and updating materials properties data, has arranged for the preparation of this book.

Zirconium-base alloys, primarily Zircaloy-2 and Zircaloy-4, are used as both fuel rod cladding, structural, and other components in the cores of light-water nuclear power reactors. In addition, zirconium-base alloys are employed as the pressure tube material in heavy-water reactors.

Creep is one of the most important parameters associated with the analysis of performance of zirconium-base alloys in a neutron environment. This book contains a summary of in-reactor creep data for zirconium-base alloys and concentrates on the analyses of these data in a manner which should be of interest to individuals involved in both the evaluation of in-reactor performance of the fuel assemblies and core structural components and the design of these components.

This book has been reviewed and approved by Subcommittee 6 of The Metal Properties Council and is published with the cooperation of The American Society for Testing and Materials.

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Related ASTM Publications

Effects of Radiation on Materials (Eleventh Conference), STP 782 (1982), 04-782000-35

Zirconium in the Nuclear Industry (Fifth Conference), STP 754 (1981), STP 754 (1981), 04-754000-35

Zirconium in the Nuclear Industry (Fourth Conference), STP 681 (1979), 04-681000-35

Manual on Zirconium and Hafnium, STP 639 (1977), 04-639000-35

Zirconium in the Nuclear Industry (Third Conference), STP 633 (1977), 04-633000-35

A Note of Appreciation to Reviewers

The quality of the text that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

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Contents

List of Figures

List of Tables

Zirconium alloys are solid solutions of zirconium or other metals, a common subgroup having the trade mark Zircaloy. Zirconium has very low absorption cross-section of thermal neutrons, high hardness, ductility and corrosion resistance. One of the main uses of zirconium alloys is in nuclear technology, as cladding of fuel rods in nuclear reactors, especially water reactors. A typical composition of nuclear-grade zirconium alloys is more than 95 weight percent[1] zirconium and less than 2% of tin, niobium, iron, chromium, nickel and other metals, which are added to improve mechanical properties Zirconium-based alloys Zircaloy-2 and Zircaloy-4 are widely used in the nuclear industry as cladding materials for light water reactor (LWR) fuels. These materials display a very good combination of properties such as low neutron absorption, creep behavior, stress-corrosion cracking resistance, reduced hydrogen uptake, corrosion and/or oxidation, especially in the case of Zircaloy-4. However, over the last couple of years, in the post-Fukushima Daiichi world, energetic efforts have been undertaken to improve fuel clad oxidation resistance during off-normal temperature excursions. Efforts have Zirconium and its alloys are widely used as a cladding for nuclear reactor fuels. Zirconium alloyed with niobium or tin has excellent corrosion properties. The high corrosion resistance of zirconium alloys results from the natural formation of a dense stable oxide o.Â Zirconium alloys, in which tin is the basic alloying element, provides improvement of their mechanical properties, have a wide distribution in the USA. A common subgroup has the trade mark Zircaloy. In case of zirconium-tin alloys, the decrease of corrosion resistance in water and steam is taken place that resulted in the need for additional alloying.