



ZIRCONIUM

in the Nuclear Industry:

Thirteenth International Symposium

Gerry D. Moan and
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Editors



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Zirconium in the Nuclear Industry: Thirteenth International Symposium

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Foreword

This publication, *Zirconium in the Nuclear Industry: Thirteenth International Symposium*, contains papers presented at the symposium with the same name held in Annecy, France, on June 10–14, 2001. The sponsor of the symposium was ASTM Committee B-10 on Reactive and Refractory Metals and Alloys.

The symposium co-chairmen were Gerry D. Moan (AECL) and Clement Lemaignan (CEA) and the editorial chairman was Peter Rudling (ANT). The editors of this STP were Gerry Moan and Peter Rudling.

Overview

This STP contains the papers presented at the Thirteenth ASTM International Symposium on Zirconium in the Nuclear Industry held in Annecy, France, in June 2001. The first symposium in the series was held in Philadelphia in 1968.

Some 200 engineers and scientists attended the Symposium from 18 countries representing the production and use of Zr alloys, their properties and behavior during nuclear service, the design of Zr components, and their testing after service. Seven sessions were devoted to the presentation of 42 papers. In addition, one session was devoted to 30 poster presentations. The papers published in this STP were given peer reviews and were edited. In addition, the most significant parts of the discussions that followed the oral presentation of each paper are included. C. Coleman (AECL) and C. Lemaignan (CEA) made presentations on historical aspects of research on Zr alloys when they received the Kroll Awards; these papers are also included.

Historically, in commercial reactors, Zircaloy-2 and -4 and Zr-1Nb alloys have been used as material for fuel assembly components, while Zr-2.5Nb materials have been used for pressure tubes. During the 1980s and 1990s, the increased corrosion observed in the "hot" Swiss and German PWR plants prompted the fuel vendors to replace the Zircaloy-4 material with more corrosion resistant materials. This situation was the driving force for the development of the various PWR corrosion resistant Zr-Nb materials and the Zircaloy materials with low Sn-contents that are commercially available today. During the last few years, increased fuel assembly deformation during service has become a concern for the utilities.

The corrosion resistance requirements in the BWR plants are still not too severe, so that the currently available Zircaloy-2 materials can be used. However, recently, shadow corrosion (an accelerated form of corrosion that occurs on the Zircaloy material adjacent to a dissimilar material such as Inconel) has become an issue.

Another issue that has emerged is the intermediate storage of spent fuel waiting to be finally disposed. In many countries, the fuel storage pools at some reactor sites will soon be full. Since the high level decisions about how spent fuel will be disposed have not yet been made, intermediate storage solutions are needed. Today, researchers are looking at "wet" and "dry" storage systems and the potential materials problems are receiving attention.

Over the last couple of years, the deregulation of the electricity market and increased competition from other sources of electricity require that the utilities reduce costs associated with maintenance and fuel, while the regulatory authorities require that safety margins be enhanced. These requirements may be reached by increased fuel burnup, by more aggressive fuel management schemes and by increased operating flexibility (such as load following). Utilities are implementing changes to the water chemistry to control increases in the plant system radiation and to decrease tendency for stress corrosion cracking in reactor components. The changes may lead to more issues associated with material performance in the near future.

Developing good mechanistic models will lead to improved understanding of the behavior of the Zr alloys and components during service. This will allow the fuel vendors and the utilities to modify the microstructures and properties of the materials and to optimize the reactor operating conditions, so that fewer material performance issues will be encountered in the future.

The current material related issues are well reflected in the papers and in the poster displays presented at the Annecy Symposium. Corrosion and hydriding behavior are the most important current issues, and about one half of the papers were related to them. In-reactor studies formed the basis for about one quarter of the papers. Also, two papers were related to the behavior and properties of Zr alloys for the intermediate storage of spent fuel. Other papers covered basic metallurgy, including studies of second phase particles, irradiation creep and growth, material performance during LOCA (loss of coolant accidents), and RIA (reactivity initiated accident).

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