The Antenna

NEWSLETTER FROM A.N.T. INTERNATIONAL No.41 2018

NEW STAND ALONE REPORT!

CORROSION AND HYDROGEN PICKUP

Volume I & Volume II

Corrosion and Hydrogen Pickup – Volume I & Volume II

Corrosion and hydrogen pickup (HPU) mechanisms of Zr alloys remain a top priority of the nuclear industry. Commercial Zr alloys have today adequate in-reactor corrosion properties. However, hydrogen in fuel components limits the fuel performance today during normal operation and accident conditions as well as during transport of spent fuel, as follows:

- Loss of Coolant Accidents (LOCA)
- Reactivity Initiated Accidents (RIA)
- BWR Channel Distortion
- PWR Fuel Assembly Distortion
- Hydrogen Embrittlement / Hydride-induced Cracking
- Seismic Events
- Primary Hydriding & Secondary Degradation
- Dry Cask Storage and Transportation

The HPU in Zr alloys can be reduced by decreasing the Hydrogen Pickup Fraction (HPUF) and/or the corrosion rate since it reduces the amount of hydrogen that can be picked up by the Zr alloy. The best would of course be, to both reduce the corrosion rate as well as the HPUF. The Study of Hydrogen Impacts in Zirconium Alloy Materials (SHIZAM) managed by Dr. Erik Mader has been formed within EPRI's Fuel Reliability Program (FRP) to get a better understanding of how the hydrogen is absorbed in the Zirconium material and hydride consequencese.

Despite more than 50 years of research, the corrosion and HPU mechanisms are still not clear. Improved understanding of the in-reactor oxidation and hydrogen pickup mechanisms are thus required. To shed light on these complicated mechanisms, A.N.T. International will publish a set of two reports (Vol. I and II) with the focus on explaining the very complicated corrosion and hydrogen pickup mechanisms in an understandable manner.

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Editor & publisher: Peter Rudling

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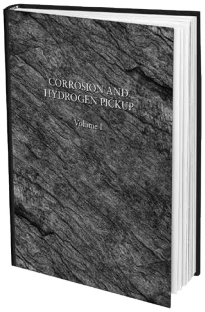
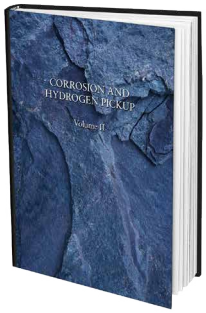
Corrosion and Hydrogen Pickup – Volume I:



- **Section 1** is an introduction to both Volume I and II
- **Section 2** gives an overview of reactor coolant chemistry in the primary circuit.
- **Section 3** describes the different fuel designs and materials used in the fuel assemblies.
- **Section 4** covers the different types of irradiation in a reactor and how it impacts structural materials and water (radiolysis).
- **Section 5** provides corrosion and HPU performance of Zr alloys.
- **Section 6** gives a description of CRUD formation, transport to fuel, deposition, activation and transport to system surfaces.
- **Section 7** covers AOA.
- **Section 8** summarises various reported cases of fuel performance issues related to coolant chemistry.
- **Section 9** gives a summary of the Report.
- **Appendix A** provides information about the effects of heat treatments on growth of second phase particles.

Corrosion and Hydrogen Pickup – Volume II:



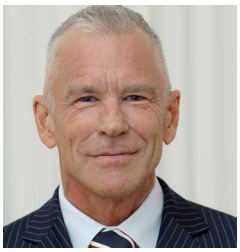
- **Section 1** gives an overview of out reactor corrosion and hydrogen pickup
- **Section 2** out-of-pile corrosion testing and their relevance
- **Section 3** gives an overview of out reactor corrosion and hydrogen pickup.
- **Section 4** provides a current scientific understanding of the corrosion and HPU mechanisms
- **Section 5** covers parameters impacting corrosion and HPU.
- **Section 7** discusses modelling of the corrosion kinetics
- **Section 8** supplies information on corrosion resistant Zr alloys
- **Section 9** gives a summary of the Report

THE AUTHORS

Mr. Friedrich Garzarolli retired from Framatome ANP in March 2002, where he has held various managerial and research positions, dealing with fuel rod performance analysis, planning and evaluation of irradiation tests, materials characterisation and evaluation of irradiation effects in materials. His degree as Diplom Ingenieur in metallurgy was obtained from the University of Leoben, Austria, in 1963. He has been active in the following fields:

- Development of new fuel assembly materials, especially cladding for BWRs and PWRs
- Modelling of corrosion for zirconium alloys and stainless steels
- Effect of water chemistry on cladding corrosion
- PCI failures of cladding
- In-reactor dimensional stability
- High-burnup performance
- Failure mechanisms and remedies
- Microstructure evolution due to reactor irradiation

Dr. Clément Lemaignan, born in 1949, graduated in material science from school of Mines, St Etienne, got his MS in metallurgy from MIT and his PhD from Polytechnicum of Grenoble. He worked during his entire carrier at the Grenoble Nuclear Center in the field of Nuclear Metallurgy, on fuel behaviour, irradiation damage and RPV embrittlement and mostly focussing on Zr alloy behaviour under irradiation and corrosion. Retired form CEA, he acts currently as scientific consultant and advisor for various nuclear agencies or companies. Emeritus Professor at INSTN (CEA Paris) of nuclear metallurgy, physics of irradiation damage and fracture, Prof. Lemaignan holds 3 patents, has authored 3 books, 6 book chapters, and over 80 peer-reviewed articles. He has been editor for the Journal of Nuclear Materials for more than 15 years. For his research and teaching, Prof. Lemaignan has received many distinctions, among them the Kroll award from ASTM in 2001.



Mr. Peter Rudling is the President of A.N.T. International, managing the ZIRAT/IZNA/LCC Programmes as well as providing seminars and Handbooks on various fuel related topics to the nuclear industry. Peter was a senior consulting scientist at Vattenfall, the largest Swedish power company. Earlier he has also been a Specialist of Fuel Materials at ABB Atom (now Westinghouse) and a Project Manager at EPRI.

ASSOCIATED SEMINAR

Zr Alloy Corrosion and Hydrogen Pickup Mechanisms

Palma de Mallorca, March 14-15, 2019

There will be an associated 2 day seminar in Palma de Mallorca, Spain in March 2019 covering the topics in Vol. I and II.

The lecturers: Mr. Friedrich Garzarolli, Dr. Clément Lemaignan & Mr. Peter Rudling.

During the seminar, the following topics will be addressed:

1. Zr Alloy Corrosion and HPU — Introduction
2. Irradiation, Types and Effects
3. Design Criteria (Oxide Thickness and Hydrogen Content)
4. Out-of-Reactor Corrosion and HPU, Testing and Relevance
5. In-reactor Corrosion and HPU (PWR, VVER, CANDU and BWR)
6. Current Scientific Understanding of the Corrosion and HPU Mechanisms
7. Parameters Impacting Corrosion and HPU
8. Modelling the Corrosion Kinetics
9. Comparison of Current Alloy Experience
10. CRUD and AOA
11. Cases of Accelerated Corrosion and HPU in the Industry

A.N.T. INTERNATIONAL ACADEMY – SEMINAR PRICES

2-DAY SEMINAR

No. of participants	1	2	3	4	5	6	7	8
Price p/p (EUR)	2 500	2 375	2 375	2 250	2 250	2 000	2 000	2 000
Total price (EUR)	2 500	4 750	7 125	9 000	11 250	12 000	14 000	16 000

Contact us for more information: *seminar@antinternational.com* or +46 (0)31-88 16 00

CLICK HERE TO REGISTER TO THIS SEMINAR

Contact

For more information and/or an offer welcome to contact us at *sales@antinternational.com*

Please also visit our website for the latest updated information, *www.antinternational.com*

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