The Antenna

NEWSLETTER FROM ANT INTERNATIONAL No.31 2017

Don't miss our upcoming ANT International Academy Seminars 2017

We are pleased to announce the arrangements for the ANTIA Seminars.

The ANTIA Seminars will take place in the same venue as the ZIRAT seminar in USA and the LCC/ZIRAT Seminars in Mallorca, Spain. The maximum number of participants in each Seminar will be 25. Participants will be determined on a first registered, first served basis .

Please note:

The Dry Storage Seminar by Dr. Albert Machiels and Mr. Friedrich Garzarolli has been cancelled but will be given in March 2018.



FEBRUARY-MARCH 2017

Monday 13	Tuesday 14	Wednesday 15	Thursday 16	Friday 17	Saturday 18	Sunday 19
ZIRAT21 Seminar, USA			ANTIA: Delayed Hydride Cracking in Zirconium Alloys			
MARCH 2017						
Monday 27	Tuesday 28	Wednesday 1	Thursday 2	Friday 3	Saturday 4	Sunday 5
	ANTIA: Maintaining Nuclear Reactor Components Performance and Integrity for Plant Safety.					
Monday 6	Tuesday 7	Wednesday 8	Thursday 9	Friday 10	Saturday 11	Sunday 12
ZIRAT21 Seminar, Spain			ANTIA: Scientific backgrounds for the			
LCC12 Seminar, Spain			behaviour of Zr alloys in nuclear reactor.			
			ANTIA: T/H in PWR Fuel.			

MAINTAINING NUCLEAR REACTOR COMPONENTS PERFORMANCE AND INTEGRITY FOR PLANT SAFETY

The presentation will be given by Dr. Ulf Ilg and Mr. Francois Cattant in Mallorca, Spain.



Seminar Agenda

- 1. Brief description of the various types of LWRs and of their main components relevant for safety
- 2. Materials and materials properties
- 3. Review of Non Destructive Testing technologies used in LWRs
- 4. WENRA Safety Level, Issue I: Ageing Management
- 5. Field experience with PWR components:
 - a. Reactor Pressure Vessel (RPV) and RPV internals
 - b. Pressurizer
 - c. Steam Generator
 - d. Reactor Cooling System (RCS), piping and main coolant pumps
 - e. Systems attached to the RCS: CVCS, SIS, RHR, CCS, ...
 - f. Balance of plant
- 6. Field experience with BWR components
 - a. Core shroud
 - b. Austenitic stainless steel piping systems
 - c. Ferritic steel piping systems
 - d. Dissimilar welds incl. CRDM-nozzles
- 7. Refurbishing concepts in case of degradation incidents (BWR)
 - a. Optimised materials
 - b. Optimised manufacturing processes
 - c. Optimised material selection and manufacturing of dissimilar welds
- 8. Degradation in LWR components and Mitigation Techniques
 - a. Boric acid corrosion
 - b. Degradation by foreign objects
 - c. Wear issues
 - d. Corrosion mitigation techniques
- 9. Operational surveillance and measures to maintain component performance or

reduction of dose rate

- a. Temperature transients with regard to fatigue
- b. Control of water chemistry in BWR (e.g. Co-60 activity after replacement control rods) with regard to reduce the dose rate of the plant
 - c. Irradiation samples in the frame of surveillance program (Post characterisation of irradiated RPV material, PWR as well as BWR)
- 10. Brittle fracture analysis of RPV in case of PTS (pressurized thermal shock) in PWR
- 11. Integrity concept for piping systems with corresponding leak and break postulates in LWR to ensure long term operation

SCIENTIFIC BACKGROUNDS FOR THE BEHAVOIOUR OF ZR ALLOYS IN NUCLEAR REACTOR

The presentations will be given by *Clement Lemaignan in Mallorca, Spain.*



Seminar Agenda

- 1. Need to control microstructure of Zr alloys
- 2. Classical approach : Thermodynamics and kinetics
 - a. Interests and limitations
 - b. Specific case of Zr (solubility's, $(\beta \Rightarrow \alpha)$, ...)
 - c. Impact of irradiation
- 3. Computational Material Science
 - a. Interactions between atoms
 - b. History of advances
 - c. Describing phase transformations at atomic scale
 - d. Atomic evolution of defects (clustering, diffusion..)
 - e. Control of phase transformations kinetics
- 4. Transfer of scientific techniques or concepts
 - a. Ti alloys and $(\beta \Rightarrow \alpha)$
 - b. Steels and "High Entropy Alloys"
 - c. Progresses in data acquisition
 - i.Accuracy, speed, volume
 - ii. Atom probe, 3D-4D tomography and crystallography
- 5. Prospects

T/H SEMINAR ON PWR FUEL

The presentations will be given by Mr. Kenneth Epperson in Mallorca, Spain.

Seminar Agenda

1. Neutronics (1 hour)

- a. Basic Equations, including key assumptions for PWR application
- b. Relationship of key reactivity components to fuel design
 - i. Enrichment
 - ii. Moderator
 - iii. Poisons
- c. Safety Criteria for Cycle Operation
 - i. Local Peaking
 - ii. Shutdown Margin
- d. Key parameters for Fuel Design, Cycle Design, and Required Cycle Analyses

2. Thermal Hydraulics (2 hours)

- a. Basic Equations, including key assumptions for PWR application
- b. Forms of Heat Transfer in PWRs
 - i. Conduction
 - ii. Convection
 - iii. Subcooled Nucleate Boiling
- c. Safety Criteria for Cycle Operation
 - i. Defined and describe DNB, DNBR, CHF
 - ii. Explain CHF correlation development and application
 - iii. Show relationship of fuel analysis to system functions
- d. Key parameters for Fuel Design, Cycle Design and Required Cycle Analyses
- 3. Fuel Rod Mechanical (1/2 hour)
 - a. Basic Equations, including key assumptions for PWR application
 - b. Safety Criteria for Cycle Operation
 - i. Fuel Melt and Internal Fuel Rod Pressure relationship to Neutronics and T/H criteria
- 4. Application of Fundamentals to Operating Anomalies (1/2 hour)
 - a. Two examples of how understanding the basic physics of the system can help in
 - identifying and explaining unexpected operating anomalies
 - i. Crud Induced Power Shift (CIPS)
 - ii. Reactor Coolant System flow changes



Detailed Outline

1. Neutronics (1.5 hrs)

- a. Basic Equations, including key assumptions for PWR application
 - i. Keffective
 - ii. Inhour Equation and Delayed Neutrons
 - iii. Reaction Rate Equation
- b. Relationship of key reactivity components to fuel design
 - i. Enrichment number density effect on RR equation
 - ii. Moderator Flux effect on RR equation
 - iii. Poisons Flux effect on RR equation
- c. Safety Criteria for Cycle Operation
 - i. Local Peaking FdelH and Fq limits (CFM limits in Mechanical section), why peaking??
 - ii. Shutdown Margin Requirements related to Keff and Inhour equations
- d. Key parameters for Fuel Design, Cycle Design, and Required Cycle Analyses
 - i. Energy Requirements and Cycle Length/Capacity Factor
 - ii. Peaking limits nominal design versus accident analysis limits
 - iii. SS Protection (DNB Limit Line)
 - iv. Ch 15 Transient analysis limits
- 2. Thermal Hydraulics (1.5 hours)
 - a. Basic Equations, including key assumptions for PWR application
 - i. Laws of Thermo
 - b. Forms of Heat Transfer in PWRs
 - i. Conduction conduction equation derivation in cylindrical coordinates
 - ii. Convection Bernoulli's equation and Navier-Stokes
 - iii. Subcooled Nucleate Boiling Subcooled boiling curve, stagnant pool and Flow Boiling curves
 - c. Safety Criteria for Cycle Operation
 - i. Defined and describe DNB, DNBR, CHF terms
 - ii. Explain CHF correlation development and application fits, forms, code tie, smooth versus saw-toothed functions, need for license limit controls
 - iii. Show relationship of fuel analysis to system functions core boundary conditions versus system response
 - d. Key parameters for Fuel Design, Cycle Design and Required Cycle Analyses
 - i. Peaking limits nominal design versus accident analysis limits
 - ii. SS Protection (DNB Limit Line)
 - iii. Ch 15 Transient analysis limits

3. Fuel Rod Mechanical (0.33 hour)

- a. Basic Equations, including key assumptions for PWR application
 - i. Ideal Gas Law
 - ii. CFM equation show no geometry dependence
 - iii. Corrosion
- b. Safety Criteria for Cycle Operation
 - i. Fuel Melt and Internal Fuel Rod Pressure relationship to Neutronics and T/H criteria
 - CFM limits
 - Clad Liftoff
 - Strain
 - LOCA component

4. Application of Fundamentals to Operating Anomalies (1/2 hour)

- a. Two examples of how understanding the basic physics of the system can help in
 - identifying and explaining unexpected operating anomalies
 - i. Data acquisition difference between analog and digital
 - ii. Need to understand and deal with limitations of data source
 - iii. Critical flaw of single indication assessment
- b. Crud Induced Power Shift (CIPS)
 - i. Observations
 - ii. Testing hypotheses
 - iii. Postulations based on physics
 - iv. Conclusion/Confirmation based on historic review
- c. Reactor Coolant System flow changes
 - i. Observations
 - ii. Testing Hypotheses
 - iii. Postulations based on physics
 - iv. Benefit of data averaging in signal resolution

DELAYED HYDRIDE CRACKING IN ZIRCONIUM ALLOYS

The presentation will be given by *Kit Coleman in Clearwater, USA.*



Seminar Agenda

- 1. Introduction to Delayed Hydride Cracking (DHC).
- 2. Component failure by DHC.
- 3. Hydrogen in zirconium alloys:
 - a. Solubility limits
 - b. Diffusivity
- 4. Hydride properties:
 - a. Crystallography
 - b. Mechanical properties
- 5. Basic mechanism of DHC
- 6. Implications of mechanism for behaviour of a crack
- 7. Experimental methods
- 8. Phenomenology and dependencies on:
 - a. Time
 - b. Stress and stress intensity factor
 - c. Temperature history and distribution
 - d. Microstructure
 - e. Strength
- 9. Models of crack growth by DHC
- 10. Implications for structural integrity
 - a. During operation Leak-before-break
 - b. During storage of spent nuclear fuel

HOTEL IN USA



February 13-16, 2017

Sheraton Sand Key Resort 1160 Gulf Blvd., Clearwater Beach, 33767 Florida, USA Phone: +1 727 595 1611 Fax: +1 727 593 6004 Web site: http://www.sheratonsandkey.com

For room reservations please visit: Reservation online. If you need assistance, please contact Angela Olpretean at e-mail: <u>angela.olpretean@antinternational.com</u> or phone: +46 (0) 70-263 13 77. Singles/doubles rate is USD 192 plus tax, per night. A number of rooms are being held for the nights of Feb 12–Feb 16. (checking out on Feb. 17). The reservation cut-off date was January 13th. The breakfast will be hosted by ANT International.



HOTEL IN SPAIN



March 6-10, 2017

Meliá Palas Atenea Paseo Marítimo, 29 07014 Palma de Mallorca, Spain Phone: +34 971 22 27 60 Fax: +34 971 45 15 28 Web site: Palas Atenea Hotel

For room reservations please visit: <u>Reservation online</u>. If you need assistance, please contact Angela Olpretean at e-mail: <u>angela.olpretean@antinternational.com</u> or phone: +46 (0) 70-263 13 77. Standard room rate is EUR 100, per night (10% taxes and breakfast included). A number of rooms are being held for the nights of March 6–10 (checking out on March 11). The Meliá Palas Atenea is located 8 km from the airport. The resevation cut-off date was January 15th.



SEMINAR REGISTRATION

In addition to hotel/room reservation, you must also register for the Seminars that you will attend (if you have not already done so). Attention! <u>Each participant</u> must be registered for the seminar.

Before the Seminar, the presentation material will be made available to the participants. This will enable the participants to prepare hardcopies of the material to bring to the Seminar, if desired. After the Seminar, a certificate of seminar attendance will be issued by ANT International to the participants.

Please contact Angela Olpretean at e-mail: angela.olpretean@antinternational.com or phone: +46 (0) 70-263 13 77 for further inquiries and questions.

We are looking forward to meeting you.

Afella

With best regards, Peter Rudling President Advanced Nuclear Technology International



Office Address: Advanced Nuclear Technology International, Analysvägen 5, SE-435 33 Mölnlycke, Sweden. Phone: +46 (0)31-88 16 00. Fax: +46 (0)31-88 16 01. info@antinternational.com www.antinternational.com