

## **NOMATEN SEMINAR**

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**Wtorek, 1 czerwca 2021 g. 13.00-14.30**  
**Tuesday, June 1st 2021 at 1PM-2.30PM CET**

### **Title:**

**Neutron-Irradiated Microstructure of Light Water Reactor Materials**

### **Speaker:**

**Dr. Wade Karlsen VTT Technology Institute of Finland (NOMATEN CoE Partner)**

### **Abstract:**

The safe, long-term operation of light water reactors for power generation can be limited by irradiation-induced aging of the materials, which is manifested in the microstructure via a number of phenomena. Analytical scanning transmission electron microscopy is a powerful tool for investigating the manifestation of neutron-irradiation on materials. This talk will give an overview of irradiation-induced microstructural phenomena present in austenitic stainless steel reactor pressure vessel internals materials, by utilizing examples from various materials at different dose levels from different reactor components. They include examples from bolts, plates, and thimble tubes, with neutron irradiation levels from 2.9 dpa up to 100 dpa, which have been examined at VTT by analytical transmission electron microscopy.

## **Bio:**

Dr. Wade Karlsen is a Principal Scientist at VTT Technical Research Centre of Finland, where he also serves as the Technology Manager for the new VTT Centre for Nuclear Safety hot laboratory facilities. He was granted a Ph.D. in Materials Science and Engineering from the Oregon Graduate Institute of Science and Technology, U.S.A. (now Portland State University) in 1997. He then took a post-doctoral research scientist position in the Laboratory of Engineering Materials of Helsinki University of Technology (now Aalto) in Finland. In 2004 he joined VTT's nuclear materials research group, focused on nuclear power plant materials degradation due to environmental effects, thermal aging and neutron irradiation. His primary specialty is in analytical transmission electron microscopy, particularly of radiation defects and radiation-induced segregation. In his role as Technology Manager he is familiar with the utilization of mechanical testing, autoclave exposure and bellows-driven special mechanical testing devices for study of materials performance, particularly of neutron-irradiated materials in the hot cell environment.

## **Selected publications illustrating capabilities and applications:**

Ken R. Anderson, Wade Karlsen, Mykola Ivanchenko, Jesse J. Carter, Richard W. Smith "Microstructural examination of zirconium alloys following in-pile creep testing in the HALDEN reactor", *Journal of Nuclear Materials* 513 (2019) 260-270.

Wade Karlsen, Mykola Ivanchenko, Janne Pakarinen, Torill Karlsen "TEM examination of the effect of post-irradiation annealing on 7.7 dpa AISI 304 stainless steel" Fontevraud 8 - Contribution of Materials Investigations and Operating Experience to LWRs' Safety, Performance and Reliability, 15 - 18 September 2014, Avignon, France. SFEN (2014), 11 p.

Ulla Ehrnstén, Janne Pakarinen, Wade Karlsen, Heikki Keinänen "Investigations on core basket bolts from a VVER 440 powerplant", *Engineering Failure Analysis* Vol. 33, 2013, pp.55-65

Wade Karlsen, Janne Pakarinen "TEM investigation of plant-irradiated NPP bolt material", Halden, Norway: Insitutt for energiteknikk, OECD Halden Reactor Project. Proceedings EHPG Meeting 2013, Enlarged halden programme group meeting, Storefjell, Norway, 11-14 March 2013

Wade Karlsen, "Grain boundary segregation in a 24 dpa 304stainless steel after post-irradiation annealing" Halden, Norway: Insitutt for energiteknikk, OECD Halden Reactor Project. Proceedings EHPG Meeting 2011, Enlarged Halden Programme Group Meeting, Sandefjord, Norway, 3-6 October 2011

Wade Karlsen, Janne Pakarinen, Aki Toivonen, Ulla Ehrnstén, "Deformation microstructures of 30 dpa AISI 304 stainless steel after monotonic tensile and constant load autoclave

testing: The Minerals, Metals & Materials Society. 15th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, Colorado Springs, CO; August 7-11,2011, Vol. 2, Pp. 1352 – 1366

Wade Karlsen, Steven Van Dyck "The effect of prior cold-work on the deformation behaviour of neutron irradiated AISI 304 austenitic stainless steel" Journal of Nuclear Materials, Volume 406, Issue 1, 1 November 2010, Pages 127-137

Maxime Sauzay, Karine Bavard, Wade Karlsen "TEM observations and finite element modelling of channel deformation in pre-irradiated austenitic stainless steels – Interactions with free surfaces and grain boundaries" Journal of Nuclear Materials, Volume 406, Issue 1, 1 November 2010, Pages 152-

Ulla Ehrnstén, Tapio Saukkonen, Wade Karlsen, Hannu Hänninen, "Deformation localisation and EAC in inhomogenous microstructures of austenitic stainless steels", 14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, Virginia Beach, VA, August 23-27, 2009.

Karlsen Wade, Toivonen Aki, Ehrnstén Ulla, "Post-irradiation microstructure and mechanical behavior of a highly-irradiated core internal component material", Proceedings of the Enlarged Halden Programme Group Meeting-Fuel & Materials, Loen, Norway, 18-23 May 2008, Session F4, Paper 8, 16p., HPR-369, Vol. 2, (2008)

Karlsen, Wade; Dohi, Kenji; Onchi, Takeo, "Observations of channel deformation in mildly-deformed, low-dose 304L austenitic stainless steel", 13th International Conference on Environmental Degradation of Materials in Nuclear Power Systems. Whistler, B.C., Canada, August 19 - 23, 2007. Canadian Nuclear Society, CNS (2007), 12 s

Onchi, Takeo; Hohi, Kenji; Navas, Marta; Karlsen, Wade; "Crack Initiation Mechanism in Non-ductile Cracking of Irradiated 304L Stainless Steels under BWR Water Environment"; Journal of Nuclear Science and Technology . Atomic Energy Society of Japan. Vol. 43 (2006) No: 8, 851-865