PAUL SCHERRER INSTITUT

PSI

Wir schaffen Wissen – heute für morgen

Pt deposition behaviour in boiling water reactors: the NORA project

S. Ritter, P.V. Grundler, L. Veleva

Paul Scherrer Institut
Nuclear Energy and Safety Research Department
5232 Villigen PSI, Switzerland

Certified System SWISSTS ISO 9001

Introduction: Principle of SCC mitigation by NMCA

Major cause of materials degradation in BWRs: SCC

↓

Mitigation of SCC in piping and reactor internals

↓

Reduction of electrochemical corrosion potential (ECP)

↓

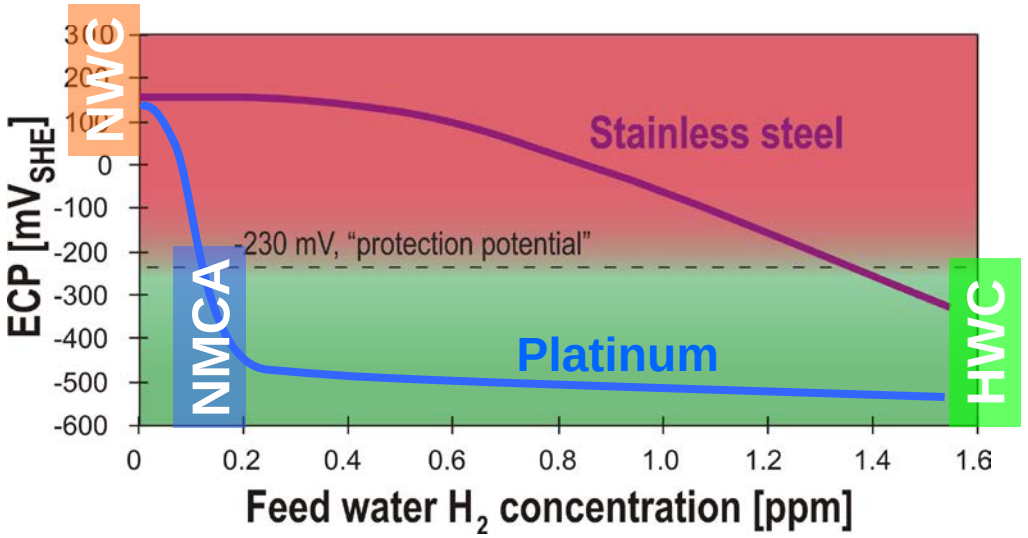
Hydrogen water chemistry (HWC)
(6 of 19 European BWRs,
35 of 35 US BWRs)

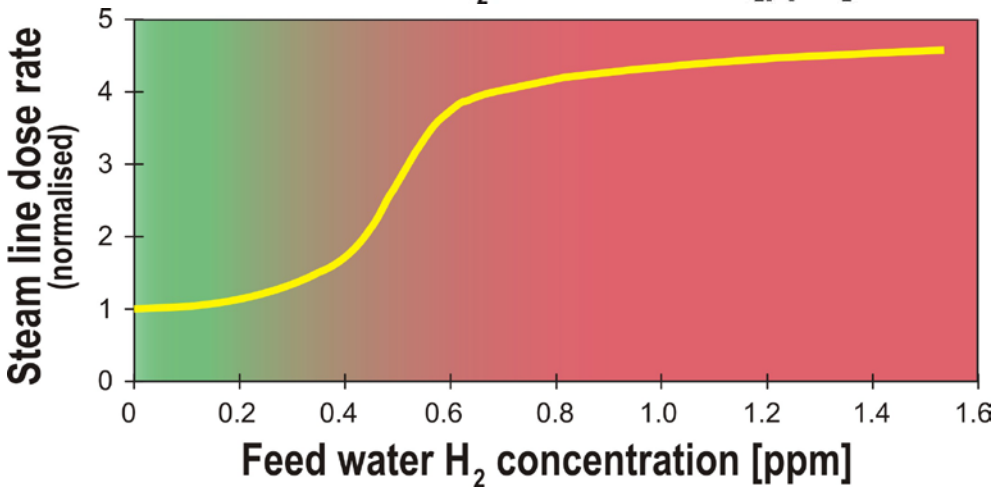
↓

Main steam line **radiation increase** (release of N-16)

↓

NMCA/NobleChem™





[Adapted from S. Hettiarachchi, et al., 7th Int. Conf. on Nucl. Eng., 1999]

Principle of the NMCA technology

Injection of noble metal compounds into reactor water (NMCA/NobleChem™)

↓

Deposition of Pt particles on water-wetted surface of structural materials

↓

Catalytic surface → faster and better recombination of H_2 with O_2 & H_2O_2

↓

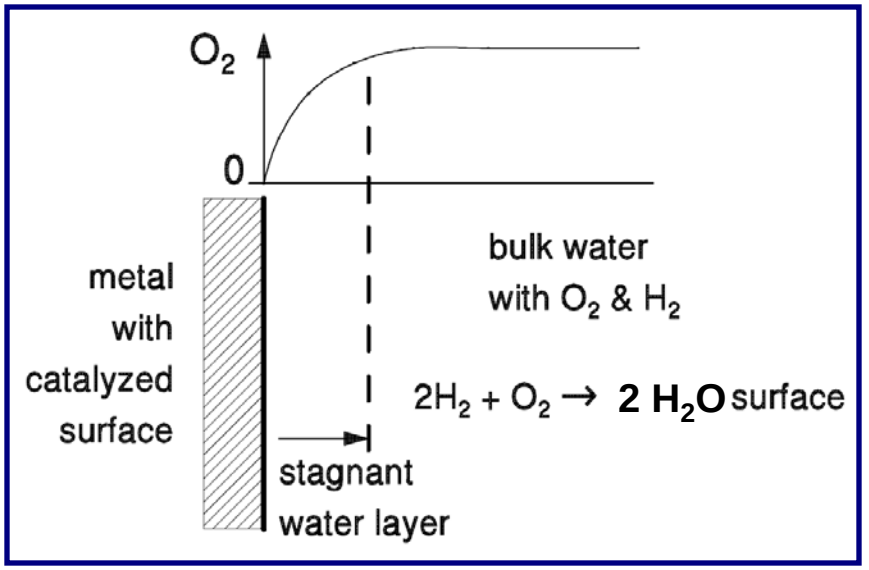
O_2/H_2O_2 conc. on the surface ≈ 0 (if stochiometric H_2 excess)

↓

Low ECP

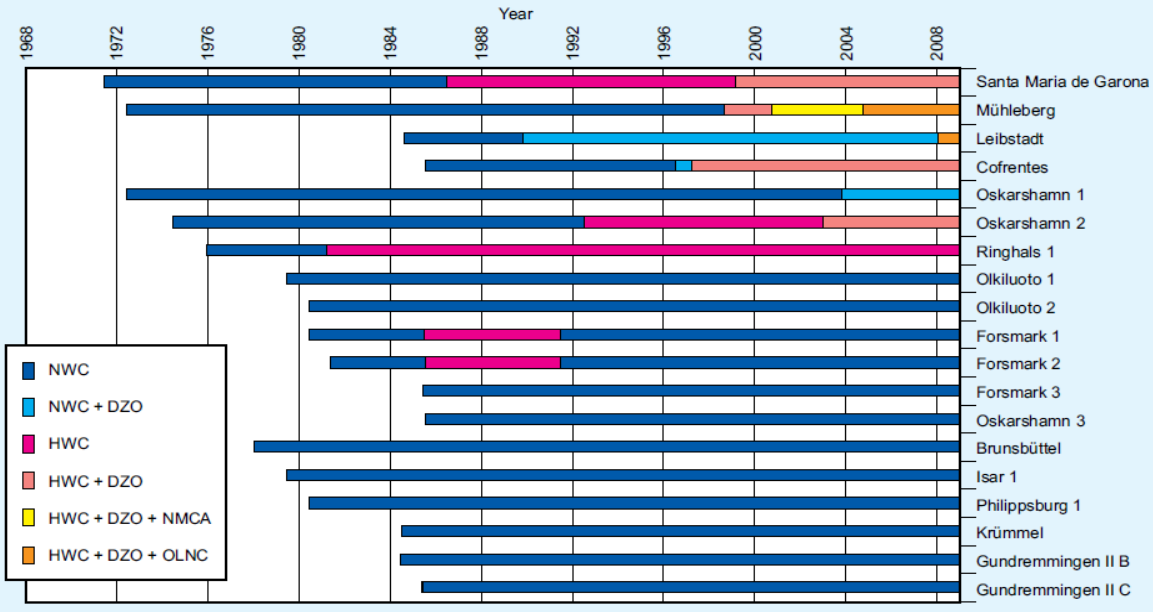
(≈ "SCC mitigation")

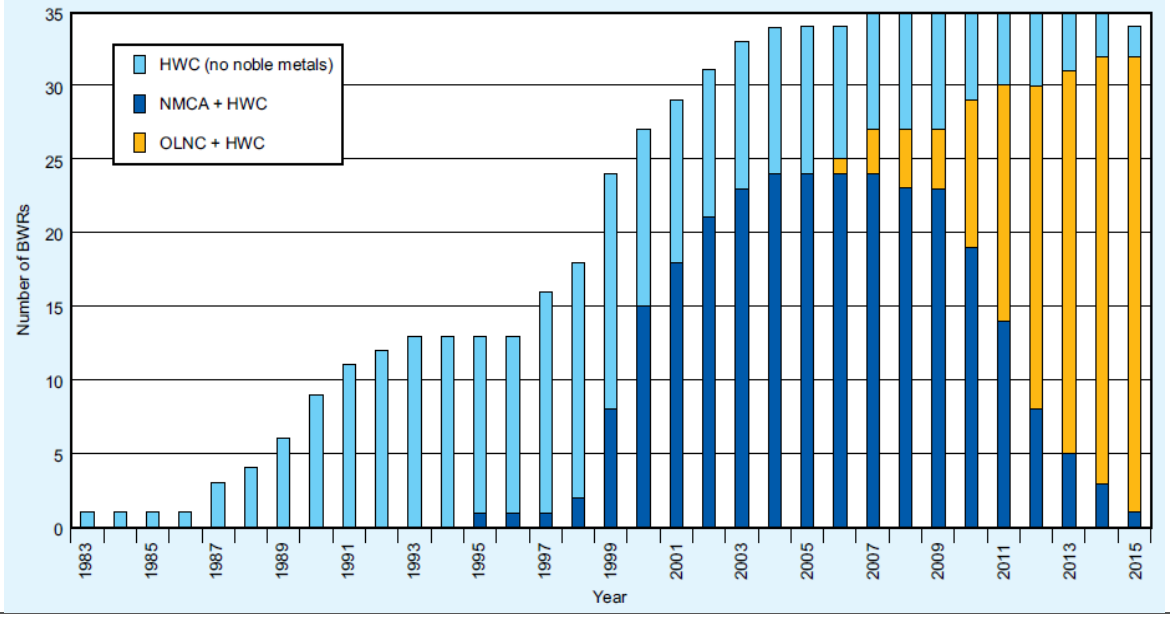
Noble metal deposition **nora** behaviour in BWRs



[P.L. Andresen, Y.J. Kim, 15th Env. Degradation Conf., 2011]

Application of NMCA in BWRs in Europe & USA (2014)





NWC

NWC + DZO

HWC

HWC + DZO

HWC + DZO + NMCA

HWC + DZO + OLNC

European BWRs:

6 x HWC, 3 x OLNC

US BWRs:

35 x HWC, 3 x NMCA,

29 x OLNC

HWC (no noble metals)

NMCA + HWC

OLNC + HWC

The NORA project

- NORA:
  Noble metal deposition behaviour in boiling water reactors
- Main objective:

  Gain phenomenological insights and a better basic understanding of the Pt distribution and deposition behaviour in BWRs.
- Duration: January 2010 – August 2016
- Project partner: ENSI, KKL, KKM
- Project coord.: S. Ritter (LNM)
- Involved personnel:
  P.V. Grundler (LNM), L. Veleva (AHL),

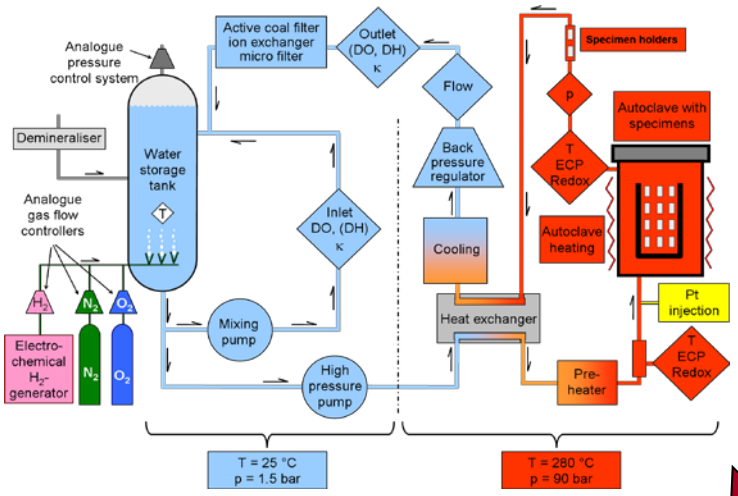
  S. Abolhassani-Dadras (LNM), B. Baumgartner (LNM),

  H.P. Seifert (LNM), I. Günther-Leopold (AHL), N. Kivel (AHL), P. Reichel (AHL), J. Kobler-Waldis (AHL), A. Ramar (AHL)

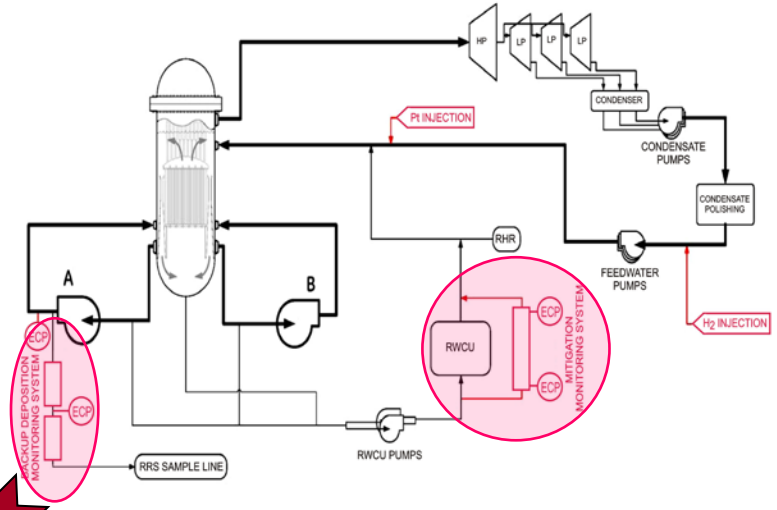
  H. Glasbrenner (ENSI), G. Ledergerber (KKL), Ch. Weber (KKM)

Assessment of the Pt distribution behaviour

Exposure of SS specimens in a HTW loop at PSI



Exposure of SS specimens in the MMS & RWSL at KKL



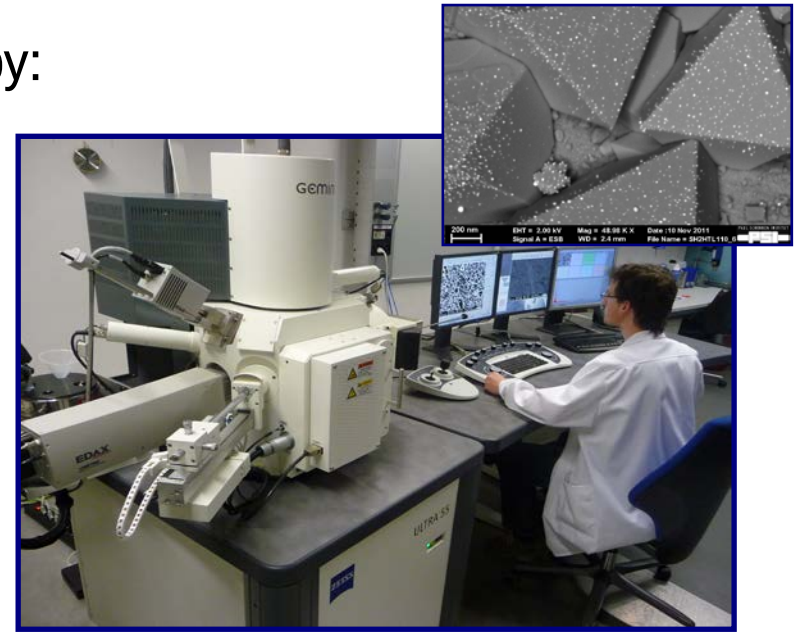
Analysis of the Pt deposition on SS specimens by:
SEM, TEM, EDX, LA-ICP-MS
(Pt particle size, distribution, concentration)

Assessment of the Pt distribution behaviour

Experimental techniques for analysis of the Pt deposition

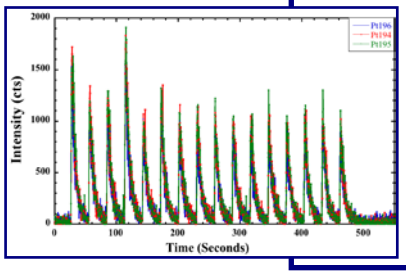
The specimens from the HT water loop (and from KKL) were analysed by:

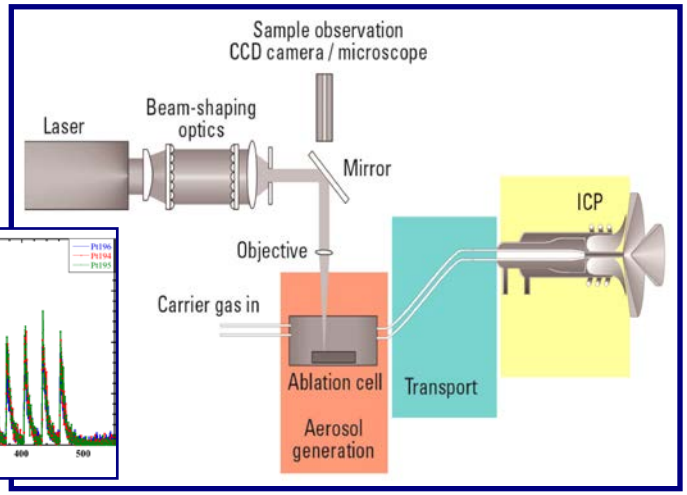
- Field Emission – Scanning Electron Microscopy:
  - Secondary electrons – topography
  - Back scattered electrons – Z-contrast
  - In-lens secondary electrons – topography
  - EDX for chemical analysis



- Transmission Electron Microscopy:
  - Diffraction contrast imaging
  - EDX for chemical analysis

- Mass Spectrometry (quantitative analysis):
  - Laser Ablation – Inductively Coupled Plasma – Mass Spectrometry





Example of Pt treated specimens