The CRP on Demonstrating Performance of Spent Fuel and Related Storage System Components during Very Long Term Storage (CRP T13014)

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International Conference on
The Management of Spent Fuel from Nuclear Power Reactors
An Integrated Approach to the Back-End of the Fuel Cycle
15-19 June 2015
Vienna International Centre, Vienna, Austria

Framework, Purpose, Networking and Funding

- Coordinated Research Projects (CRPs) are in the framework of the IAEA Coordinated Research Activities that address research and development, science and technology in the nuclear field
- Overall objectives of CRP T13014:
  - Support and share improvements in the international nuclear power community's technical basis for the renewal of spent fuel dry storage licenses
  - Results are also expected to facilitate subsequent transport and disposal of spent fuel
- This CRP is in coordination with other international efforts:
  - Extended Storage Collaboration Program (ESCP) initiated by EPRI in 2009 provided a broad context for the CRP
  - Increase coordination with similar NEA activities
- CRP funding provided through the US Peaceful Uses Initiative

Phase I and Beyond, Participants and Meetings

- Phase I: 27 June 2012 - 27 June 2016
- Like other CRPs on spent fuel (BEFAST and SPAR), the CRP on Demo could continue through Phases II (2017-2021) & III (2022-2026) in order to follow up ongoing international demonstration efforts in Japan, the Republic of Korea and the United States of America
- 15 Participants from Argentina, the European Commission, France, Germany, Japan, Lithuania, Pakistan, Poland, the Russian Federation, Slovenia, Spain, the United Kingdom and the United States of America
- First Research Coordination Meeting (RCM) held in Argentina, April 2013
- Second RCM held in Japan, November 2014
- Third (final) RCM to be held in Spain, 11-15 April 2016

Six Specific Research Objectives: Who is Addressing Them

1. **Welded Stainless Steel Stress Corrosion Cracking (SCC) Mechanisms and Monitoring**:
   Japan, Pakistan, Poland, Slovenia, UK, USA
2. **Rod Behaviour**:
   Argentina, European Commission, France, Lithuania, Spain
3. **Concrete Systems**:
   Argentina, Slovenia
4. **Bolted Closure Systems**:
   Germany, Japan
5. **Neutron Shielding**:
   France, Germany
6. **System Demo**:
   Japan

Welded Stainless Steel Stress Corrosion Cracking (SCC) Mechanisms and Monitoring

- Evaluate mechanisms for SCC as a way of breaching welded stainless steel spent fuel canisters in a marine environment
- Evaluate monitoring for SCC in order to evaluate the confinement capability of welded stainless steel canisters and to protect the integrity of the contents
- Japan, Pakistan, Poland, Slovenia, UK, USA

Metal Gasket, SCC, and Spent Fuel Performance - Japan

Research Agreement JPN 17308, Primary Chief Scientific Investigator (CSI): **Mr Koji Shirai**, **Central Research Institute of Electric Power Industry (CRIEPI)**

Metal Cask Storage (Metal Gasket):

- Need: high resistance of lid structure to breach for radionuclide confinement, water exclusion, etc.;
- Continued measurement of long-term performance of metal gaskets

Concrete Cask Storage (Stainless Steel Canister): SCC of normal stainless steel

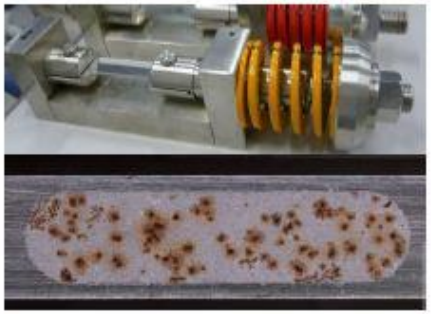
Spent Fuel Performance: Monitoring data and destructive tests

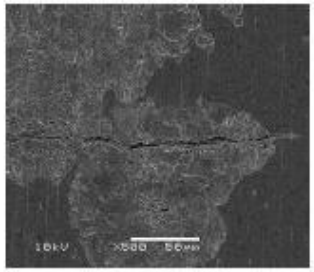
- Two-assembly long-term demonstration: special instrumented and heated cask to simulate long-term cladding temperature evolution in storage

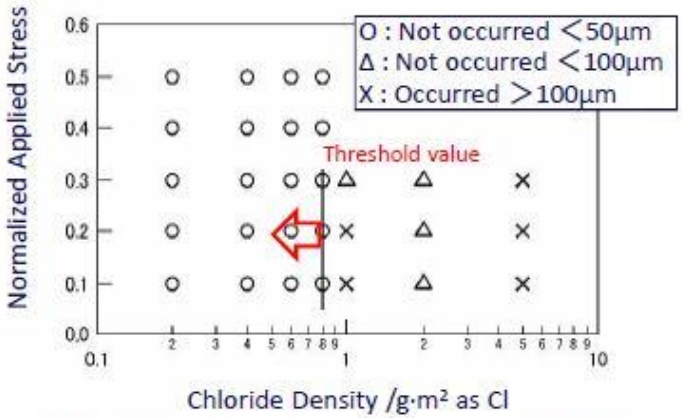
SCC Mechanisms and Monitoring - Japan

CRIEPI

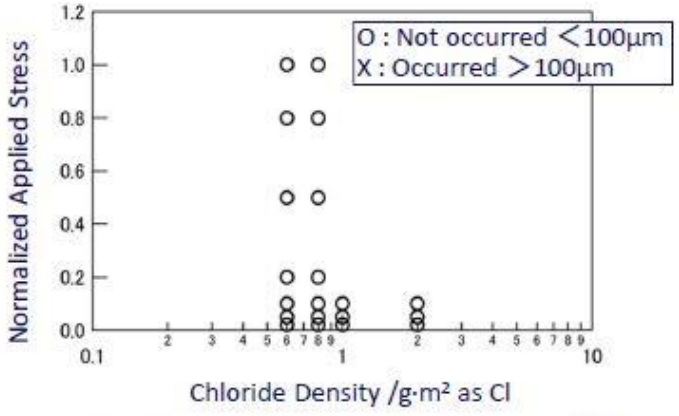
SCC Initiation Test with UNS S30403 SS







(Specimen A for 2000hr, Hardness 305Hv)



(Specimen B for 5000hr, Hardness 247Hv)

- Minimum amounts of salt for SCC initiation should be set to 0.8g/m² as Cl

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SCC Mechanisms and Monitoring - Pakistan

Research Contract PAK 17283, Primary CSI: **Mr Ammad Qureshi, Pakistan Institute of Nuclear Science and Technology (PINSTECH)**

SCC Susceptibility Studies on Welded Stainless Steel Canister Samples under Simulated Marine Environment.

- Sample characterization (ICP, XRF, SEM-EDX)
- Microstructure
- Welding technique (TIG)
- SCC susceptibility environment (sea water): corrosion rate measurements
  - Polarization resistance and Tafel plot
  - Electrochemical impedance spectroscopy

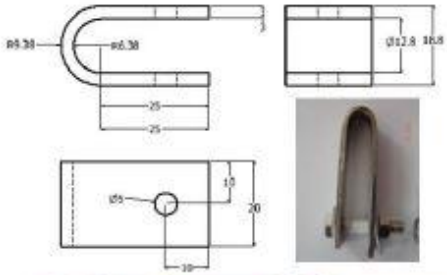
SCC Mechanisms and Monitoring - Pakistan

Salt Spray Test

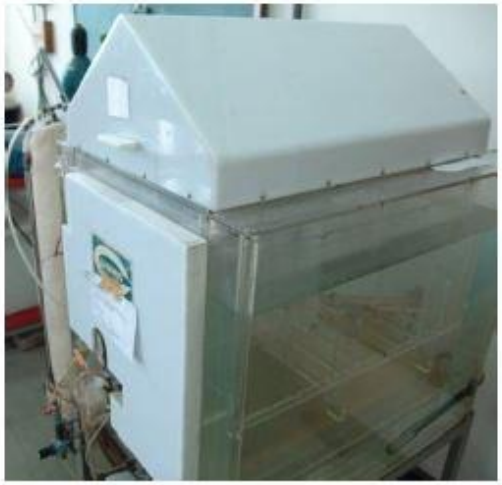
Salt Spray Test

Based on Report # NUREG/CR-7030

Atmospheric Stress Corrosion Cracking Susceptibility of Welded and Un-welded 304, 304L, and 316L Austenitic Stainless Steels Commonly Used for Dry Cask Storage Containers Exposed to Marine Environments



- Specimen Type: U-bend
- Dimension: Thickness t = 3mm
  Radius of bend R = 6.38
- Strain: ε = t/2R
- Average value = 0.23



Salt spray Cabinet

Horizontal test racks (teflon coated) for heat supply to the U-bend specimens

SCC Mechanisms and Monitoring - Poland

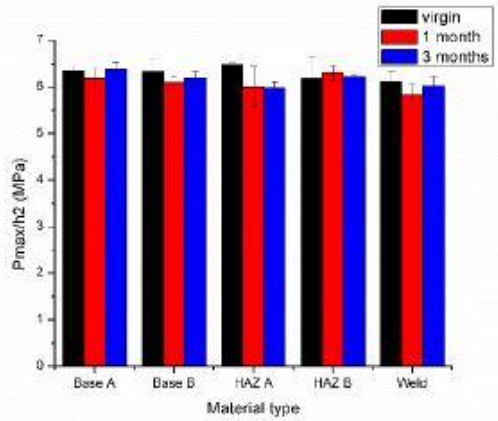
Research Agreement POL 17290, Primary CSI: **Ms Ewa Hajewska, National Centre for Nuclear Research (NCBJ)**

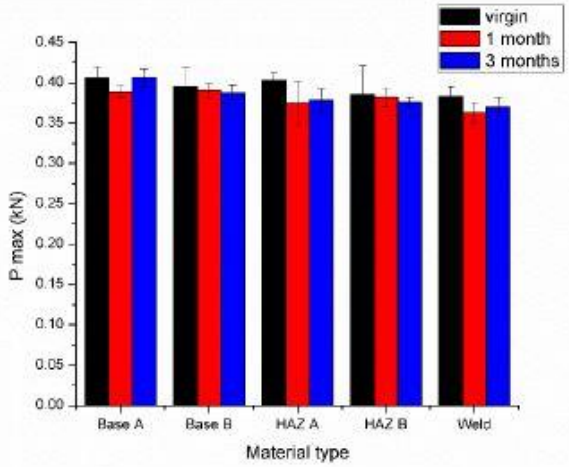
Gamma Irradiation Influence on the Mechanical and Corrosion Properties of Stainless Steel Used for Spent Fuel Containers and Canisters.

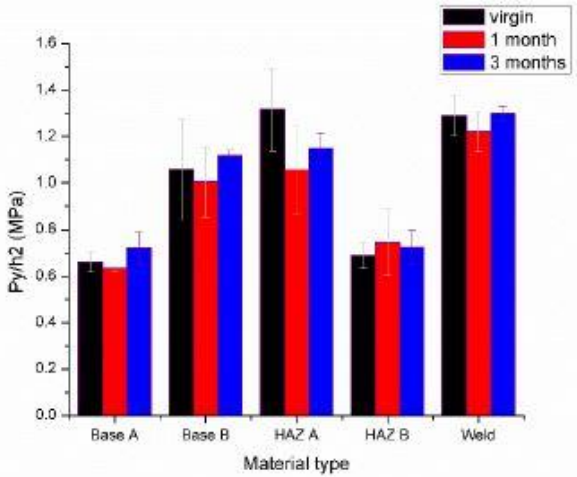
- Inter-granular corrosion
- Stress corrosion on static load and steady stress conditions. Irradiated 3 - 24 months in the spent fuel pool of the research reactor (MARIA)

1. SCC Mechanisms and Monitoring - Poland

Mechanical properties of irradiated material (1 and 3 months of irradiation)







According to the theory Pmax/h2, P max, P y and Py/h2 are proportional to the tensile strength, the maximum force recorded during he test, the Young Modulus of the material and the plasticity limit, respectively

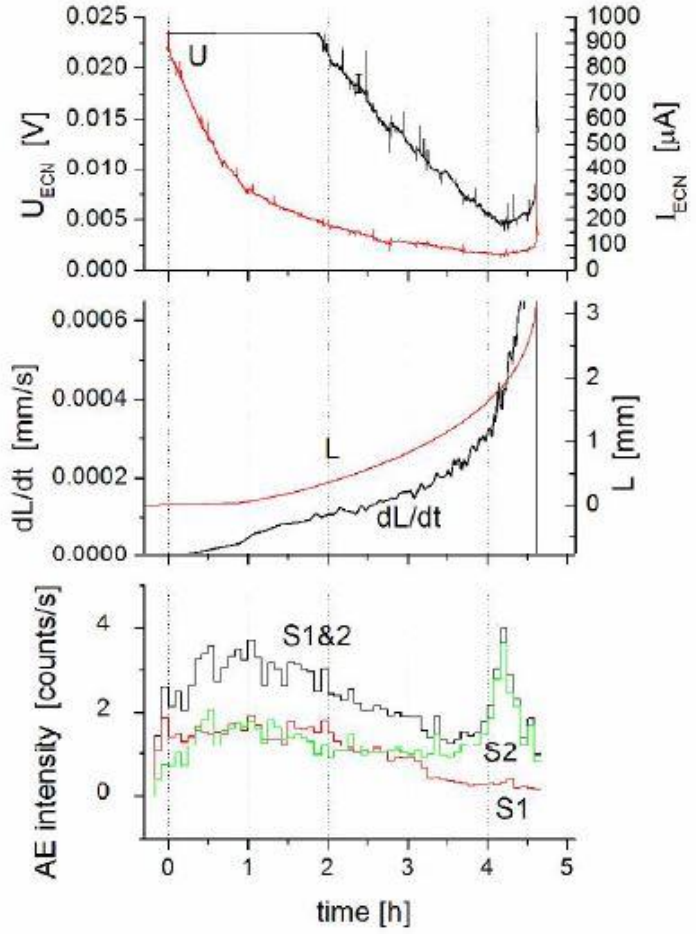
SCC Mechanisms and Monitoring - Slovenia

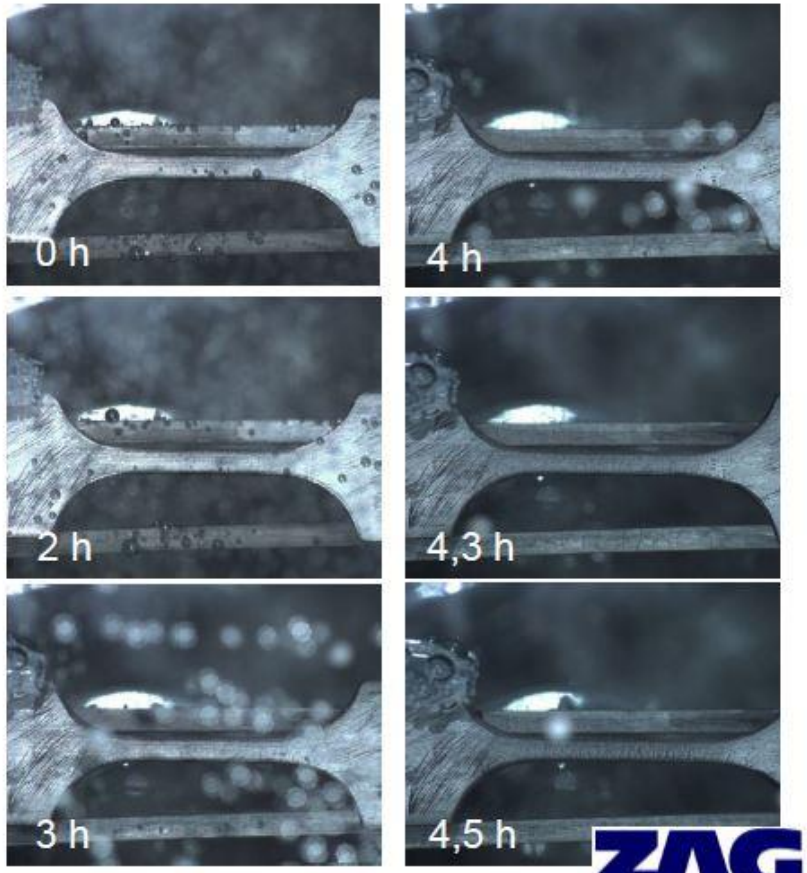
Research Contract SLO 17810, Primary CSI: **Mr Andraž Legat, Slovenian Institute for Building and Civil Engineering (ZAG)**

- Evaluation of confinement capability of concrete cask systems and monitoring of metal corrosion in concrete
- Corrosion behaviour of different SS steels analysis of conventional electrochemical techniques

SCC Mechanisms and Monitoring - Slovenia

Experiment 2: Results of ECN, AE and elongation measurements, simultaneous images capture





SCC Mechanisms and Monitoring - UK

Research Agreement UK 17420, Primary CSI: **Mr David Hambley, National Nuclear Laboratory; Central Laboratory**

SCC Monitoring:

- Development of corrosion sensors suitable for deployment in LWR cask systems
- Testing of instrumented corrosion coupons by cycling temperature and humidity and artificially inducing corrosion to quantify the systems performance

SCC Mechanisms and Monitoring - UK

Current Work

NATIONAL NUCLEAR LABORATORY

- In-situ, real time corrosion detection using environmental chamber:
  - Magnesium chloride solution applied to array of lacquered dots
  - Salt solution dried at elevated temperature leaving a salt deposit on the coupon
  - Climate chamber at elevated temperature and humidity to produce saturated salt solution
  - Crevice corrosion is expected to develop under the lacquered dots

SCC Mechanisms and Monitoring - USA

Research Agreement USA 17413 (Signature Pending), Primary CSI: To be Replaced, CI: **U.S. Nuclear Regulatory Commission (USNRC)**

Canister Chloride-Induced SCC.

- Deliquescence temperature and humidity
  - At absolute humidity less than 30 g/m^3;
  - At elevated temperatures;
  - At high relative humidity (RH) conditions;
  - At different stress/strain levels
- Minimum salt concentration for SCC

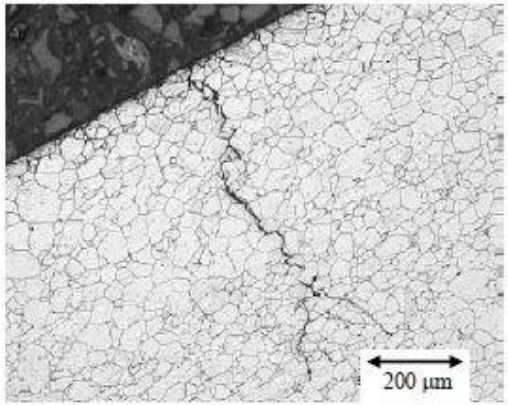
SCC Mechanisms and Monitoring - USA

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

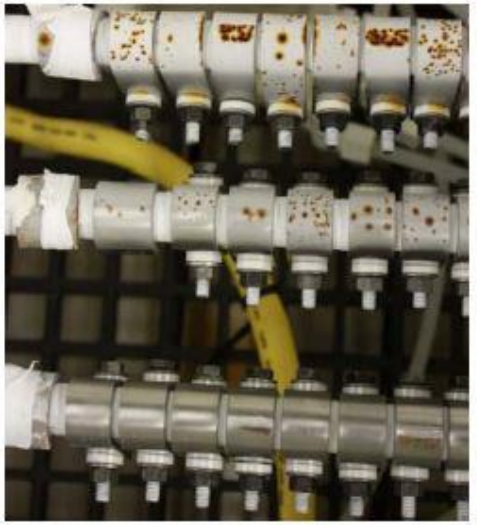
Test Results

Temperature (°C)	SCC Observed?	Lowest salt concentration at which SCC was tested and observed
27	No	N/A- salt drained from sample due to high RH
35	Yes	0.1
45	Yes	0.1
52	Yes	1
60	Yes	10

Top view of sensitized, 10 g/m^2 specimen at 60°C for 6.5 months



Cross section of sensitized, 0.1 g/m^2 specimen at 45°C after 4 months



Specimens at 10 g/m^2 (top), 1 g/m^2 (middle), and 0.1 g/m^2 (bottom)

Thank you very much for your attention!

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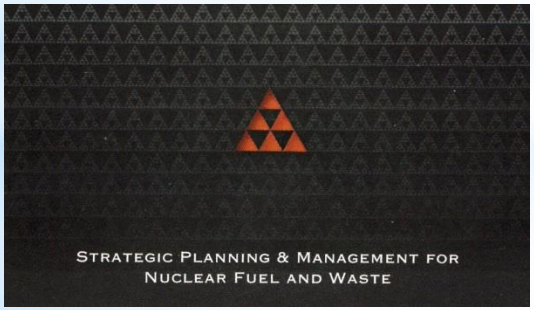

IAEA
International Atomic Energy Agency
Atoms for Peace

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