

ABSTRACTS

Development and Testing of an In-Core YSZ High-Temperature Reference Electrode

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The corrosion potential is a useful parameter to monitor the water chemistry of a nuclear power plant (NPP). However the harsh conditions in the core of a nuclear reactor make it difficult to construct a reference electrode for this location. An attempt has been made to construct such a reference electrode based on the well-known yttrium stabilized zirconia (YSZ) membrane electrode. The YSZ electrode is constructed only from radiation-resistant materials (ceramics and metals) and can survive temperatures up to 350 °C. Special emphasis has been put on the ceramic-metal seal, which is a crucial part of the design.

The YSZ electrode has been tested under PWR conditions over the course of one year (in 5 test campaigns of 3 weeks). Slight variations in the water chemistry (changes in the concentration of dissolved hydrogen) prove that the YSZ reference electrodes worked well. The corrosion potentials measured had values between -750 and -800 mV (SHE). The reference electrodes were mechanically intact after one year of testing. The electrochemical response was however no longer reliable as the electrode resistance had decreased over time. Originally this was attributed to leaking of the ceramic-metal sealing causing a "short circuit" in the reference electrode. Recent tests however have shown that the YSZ (9 weight percent yttrium) used up till now for the electrodes is not fully resistant to high-temperature water. Depending on the material structure, the lifetime varies between a few weeks to one year.

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Predicted Effect of Power Up-rating on the Water Chemistry of Commercial Boiling Water Reactors

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The approach of power up-rating has been adopted by operators of light water reactors in the past few decades in order to increase the power generation efficiency of nuclear reactors. The power up-rate strategy is apparently applicable to the three nuclear reactors in Taiwan as well. When choosing among the three types of power up-rating, measurement uncertainty, stretch power up-rating, and extended power up-rating, a deliberate and thorough evaluation is required before a final decision and an optimal selection can be made. One practical way of increasing the reactor power is to deliberately adjust the fuel loading pattern and the control rod pattern and thus to avoid replacing the primary coolant pump with a new one of larger capacity. The power density of the reactor will increase with increasing power, but the mass flow rate in the primary coolant circuit (PCC) of a light water reactor will slightly increase (usually by less than 5 %) or even remain unchanged. Accordingly, an up-rated power would induce higher neutron and gamma photon dose rates in the reactor coolant but have a minor or no effect on the mass flow rate of the primary coolant.

The radiolysis product concentrations and the electrochemical corrosion potential (ECP) values differ largely in the PCC of a boiling water reactor (BWR). It is very difficult to measure the water chemistry data directly at various locations of an actual reactor. Thus the impact of power up-rating on the water chemistry of a BWR operating under hydrogen water chemistry (HWC) can only be theoretically evaluated through computer modeling. In this study, the DEMACE computer code was modified to investigate the impact of power up-rating on the water chemistry under a fixed mass flow rate in the primary coolant circuit of a BWR/6 type plant. Simulations were carried out for hydrogen concentrations in feedwater ranging from 0.0 to 2.0 mg · kg⁻¹ and for power levels ranging from 100 % to 120 %. The responses of water chemistry and ECP to HWC at some selected locations in this BWR under different up-rated power levels were successfully evaluated. Our analyses indicated that a particular up-rate percentage would tend to promote a more oxidizing coolant environment for the structural components and therefore lead to downgraded HWC effectiveness on ECP reduction and corrosion mitigation. An 8 % or 15 % up-rate percentage led to a poorer HWC efficiency at most of the evaluated locations of this BWR. In contrast, the HWC efficiency could be slightly improved at 20 % power up-rate for most of the evaluated locations of this BWR. In summary, the impact of power up-rating on the water chemistry in the primary coolant circuit of a BWR is expected to vary from location to location and possibly from plant to plant due to different degrees of radiolysis and physical dimensions.

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Conductivity vs. pH – Comments on pH Monitoring via Conductivity Measurement

Albert Bursik

Operators of fossil power plants often do without pH monitors, instead applying data obtained through conductivity measurements to calculate the pH or compare with diagrams. This contribution looks at the quality of pH data supplied via the use of auxiliary quantities (specific and/or cation conductivity). Two approaches for pH calculation from measured conductivity are investigated. Actual and calculated pH values are compared for certain conditions, including the presence of the contaminants NaCl and CO₂. The author finds that the determination of boiler water pH (calculation) based on specific and cation conductivity measurement is relatively accurate. The calculation of feedwater pH based on specific conductivity data, however, is negatively influenced by the presence of contaminants, particularly carbon dioxide. Due to the importance of a correct pH for the plant cycle chemistry, certain application restrictions are thus imperative.

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Modification of Magnetite Film on Carbon Steel by Polyol Addition in Alkaline Condition

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The formation of oxide film on carbon steel in aqueous alkaline media with polyol was studied at high temperature (240 °C). Polyols (viz., ethylene glycol, diethylene glycol, polyethylene glycol and glycerol) modified the morphology, crystallite size and porosity of the oxide film. Oxide film formed on the metal surface under these conditions was characterized by XRD, Raman spectroscopy, SEM and electrochemical techniques. The thickness of oxide film formed under these conditions was found to be 0.7 μm after 14 days of exposure time. The results of electrochemical impedance analysis indicated that the oxide formed on the carbon steel surface in the presence of glycerol and polyethylene glycol as organic additive had higher film resistance as compared to the oxide film formed in their absence. Potentiodynamic anodic polarization studies showed lower current density for oxide film formed in the presence of 1 % (volume fraction) polyethylene glycol-400 and 1 % (volume fraction) glycerol as compared to the oxide formed in the simple alkaline condition. Raman spectroscopic (mapping) analysis showed that the film formed in the presence of polyols was of uniform single phase nature and coverage of the oxide film was complete. SEM micrographs showed that the crystallite size in the oxide film formed in the presence of glycerol was smaller as compared to the crystallites formed in the simple alkaline condition. Magnetite formed in the presence of ethylene glycol showed a broad crystallite size distribution in the film.

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A Film-Forming Additive for Layup of a 600 MW Unit with a Drum Boiler

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This paper discusses the mechanism of corrosion damage during the layup of boilers, and emphasizes the necessity of protection through proper layup procedures. A new film-forming inhibitor, WDBH, and its method of application, process controlling and film-forming effectiveness when applied during layup to protect a boiler in a unit with an air-cooled condenser are introduced. This additive has excellent film-forming qualities (good hydrophobic performance of the protective film, strong anti-corrosion characteristics), can be applied over a wide range of pH, requires only simple technology, and has great practical benefits.

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Turbine Lubricating Oil Varnish Control

Brad Buecker and Kal Farooq

Varnish formation in turbine lube oil and fluid hydraulic systems is an increasingly common problem with power generating units of many types (gas, coal, and nuclear). Varnish forms a sticky coating on surfaces inside the fluid system, including bearings, coolers, and valves, and negatively affects operation of these devices. Most notably, varnish causes stiction-induced failure of servo-valves. This article examines varnish formation fundamentals, discusses the difficulties derived thereby, and introduces a very promising control method.

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