RADIATION-INDUCED INSTABILITY OF MnS PRECIPITATES AND ITS POSSIBLE CONSEQUENCES ON IASCC OF AUSTENITIC STAINLESS STEELS - HM Chung (Argonne National Laboratory), FA Garner (Pacific Northwest National Laboratory)

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EXTENDED ABSTRACT

Irradiation assisted stress corrosion cracking (IASCC) continues to be a significant materials issue for the light water reactor industry and may also pose a problem for fusion power devices that employ water cooling. Although a number of potential mechanisms have been proposed to participate in this phenomenon, at this time it is not clear that any of these candidate mechanisms are sufficient to rationalize the observed failures.

A new mechanism is proposed in this paper that involves the radiation-induced release into solution of elements not usually thought to participate in IASCC. It is shown in this paper that MnS precipitates, which contain most of the sulphur in stainless steels, are probably unstable under irradiation. First, the Mn transmutes very strongly to Fe in highly thermalized neutron spectra. Second, the combination of cascade-induced disordering and the inverse-Kirkendall effect operating at the incoherent interfaces of MnS precipitates will probably act as a pump to export Mn from the precipitate surface into the alloy matrix. Both of these processes will most likely allow some of the sulphur to re-enter the alloy matrix. Sulphur is known to exert a deleterious influence on grain boundary cracking. MnS precipitates are also thought to be a reservoir of other deleterious impurities such as fluorine which could be also released due to radiation-induced instability of the precipitates.

This possibility has been confirmed by Auger electron spectroscopy on Types 304, 316 and 348 stainless steel specimens sectioned from several BWR components irradiated up to 3.5×10^{21} n cm^2 (E > 1 MeV). Prior to irradiation, the composition of the various analyzed precipitates was found to be nearly stoichiometric MnS. As the irradiation proceeds, however, the Mn was progressively replaced by Fe, Cr, Ni and smaller amounts of many impurities of relatively low solubility. The loss of Mn from the precipitate in favor of Fe, Ni and Cr is consistent with the strong operation of the Inverse Kirkendall effect. In order to further validate the feasibility of the MnS instability proposal, additional examination using scanning electron microscopy and electron-dispersive x-ray analysis is required. Planning for such activities is now in progress.