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Design and fabrication of four HFIR-MFE RB capsules (60, 200, 330, and 400°C) to accommodate MFE specimens preirradiated in spectrally tailored experiments in the ORR are proceeding satisfactorily. These capsule designs incorporate provisions for removal, examination, and re-encapsulation of the MFE specimens at intermediate exposure levels en route to a target exposure level of 30 displacements per atom (dpa). With the exception of the 60°C capsule, where the test specimens will be in direct contact with the reactor cooling water, the specimen temperatures (monitored by 21 thermocouples) will be controlled by varying the thermal conductance of a small gap region between the specimen holder and the containment tube. Hafnium sleeves will be used to tailor the neutron spectrum to closely match the helium production-to-atom displacement ratio (14 appm/dpa) expected in a fusion reactor first wall.*

Design and preparation of fabrication drawings for the 60 and 330°C capsules and all generic capsule components and support facilities have now been completed. Assembly of the 60°C capsule is complete and the 330°C capsule is nearing completion. The irradiation of both capsules will begin when the HFIR returns to full power operation. Design and preparation of fabrication drawings for the 200 and 400°C capsules will be completed in 1988, and operation of these two capsules will follow the first two (60 and 330°C).

1.2 Status of U.S.-Japan Collaborative Program Phase II HFIR Target Capsules (Oak Ridge National Laboratory) 7

The experiment matrix for Phase II HFIR target capsules (JP-9 through JP-16) was further revised to resolve certain discrepancies regarding specimen volume and position details. A thermal analysis to account for these changes was completed and the required new parts are on order. All eight capsules will be assembled and installed in the HFIR Simultaneously beginning with the first full power operating cycle.

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2.1 Reduced Activation Calculations at Hanford (Westinghouse Hanford Company) 12

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3.1 Materials Handbook for Fusion Energy Systems (McDonnell-Douglas Astronautics Company – St. Louis Division) 30

The effort during this reporting period has focussed on two areas: (1) publication of data pages, and (2) automation of the data pages. The data pages contained new engineering information on lithium and stainless steel along with additional Supporting Documentation pages on annealed and cold worked stainless steel. These pages were distributed in May. In the area of automation, work is proceeding on schedule toward the formation of an electronic materials data base for the MFE computer network.

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No contributions received this period

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An extensive review was conducted of a variety of radiation-induced microstructural data, searching for microstructural records of various irradiation creep mechanisms. It was found that the stress-affected evolution of dislocation microstructure during irradiation is considerably more complex than envisioned in most theoretical modelling studies, particularly in the types of interactive feedback mechanisms operating. Reasonably conclusive evidence was found for a SIPA-type mechanism (stress-induced preferential absorption) operating on both Frank loops and network dislocations. Stress-induced preferential loop nucleation (SIPN) processes may also participate but are thought to be overshadowed by the stronger action of SIPA-type processes operating on Frank interstitial loops. It was not possible to discern from microstructural evidence between second-order SIPA and first-order SIPA mechanisms, the latter arising from anisotropic diffusion. Evidence was presented, however, that validates the operation of stress-induced preferential unfaulting of Frank loops and stress-induced growth of previously stressed material following removal of applied stress. Dislocation glide mechanisms are also participating but the rate appears to be controlled by SIPA-type climb processes. Applied stresses were shown to generate very anisotropic distributions of Burgers vector in the irradiation-induced microstructure.

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6.1.1 Effects of Irradiation on Low Activation Ferritic Alloys, A Review (Pacific Northwest Laboratory) 78

A broad range of ferritic alloys is possible which satisfy the low activation requirement for near-surface burial of fusion reactor materials after decommissioning. Low activation bainitic alloys in the Fe-2Cr composition range, martensitic alloys in the Fe-7 to 9Cr range and stabilized martensitic alloys in the Fe-12Cr range have been successfully fabricated and are undergoing testing as demonstrated by efforts in Europe, Japan and the United States. However, it is found that irradiation significantly degrades the properties of bainitic and stabilized martensitic

alloys. Bainitic alloys containing vanadium develop severe hardening due to irradiation-induced precipitation at temperatures below 450°C and extreme softening due to carbide coarsening at temperatures above 500°C. Stabilized martensitic alloys which rely on manganese additions to provide a fully martensitic microstructure are embrittled at grain boundaries following irradiation, leading to severe degradation of impact properties. The most promising composition regime appears to be the Fe-7 to 9Cr range with tungsten additions in the 2% range where high temperature mechanical properties and microstructural stability are retained and impact properties are relatively unaffected by irradiation.

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6.1.3 Fractographic Examination of Low Activation Ferritic Alloy Charpy Impact Specimens (Pacific Northwest Laboratory and Westinghouse Hanford Company) 95

Miniature Charpy specimens of six low activation ferritic alloys have been fractographically examined in order to determine the effect of irradiation on impact fracture behavior. A change in brittle fracture mode due to irradiation was found for four of the six alloys. The fracture mode changed from transgranular cleavage to intergranular failure at prior austenite boundaries. The cause is ascribed to Mn additions in the alloys. Examinations also indicated that for the 9Cr-1W alloy, the DBTT as measured by absorbed energy measurements does not agree with an explanation based on fracture appearance. The cause is not yet understood.

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Compared to the simple Fe-Cr-Mn ternary alloys, the commercial alloys tended to develop less a- and ε-martensite and α-ferrite but higher levels of $M_{23}C_6$ and σ.

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6.3.1 Hydrogen Concentration Distribution in Vanadium-Base Allays after Surface Preparation and Exposure to Liquid Lithium (Argonne National Laboratory) 160

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The damage produced by neutron irradiation in the microstructures of the four vanadium alloys was qualitatively the same. Except for V-20Ti, no new precipitate phases uere observed after irradiation. Fine, rod-shaped particles were found surrounding the pre-existing titanium carhonitrides in V-20Ti. The V-15Cr-5Ti and Vanstar-7 alloys exhibited very low swelling, while V-3Ti-1Si and V-20Ti displayed slightly higher values (i.e., >0.1%). The swelling in V-3Ti-1Si increased with increasing helium content because the helium boosted cavity nucleation with only a slight loss in average cavity size.

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6.5.2 Corrosion and Mass Transfer in Lithium 12Cr-1MoVW Steel Systems (University of California – Los Angeler and Oak Ridge National Laboratory) 180

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Water-cwled, near-tern fusion reactors will operate under conditions at uhich SCC is possible; however, control of material purity and fabrication procedures can reduce the probability of crack initiation and growth. Sore of the critical issues identified in this evaluation are: 1) uill irradiation-assisted stress-corrosion cracking (IASCC) occur at temperatures lower than 100°C, and if so, is the neutron fluence threshold equal to or less than near-term reactor fluences? 2) will aqueous-salt solutions cause SCC? and 3) will radiolysis accelerate SCC in clean water or aqueous-salt coolants?

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$LiAlO_2$ and Li_2O are two candidates for tritium breeder materiels in fusion reactors which must operate within specific design temperature windows. Although irradiation may cause large reductions in thermal conductivity at room temperature, the effect at operating temperatures (T > 400°C) is much less. Hence, these solid breeder materials are expected to maintain temperatures within their initial temperature windows during operation.

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Most reports of radiation-induced changes in dielectric properties and thermal conductivities of insulating ceramics for MFE applications do not include quantitative assessments of the impact of such changes on materiel or device failure. We present details here on calculations based on a model published for some time but not applied until very recently to radiation damage. It incorporates the Weibull distribution for fracture statistics, such as used in the mid 1980's for gyrotron windows in a 'radiationless' environment. A major consequence of applying this and another model in the context of an alumina (α-Al_2O_3) or beryllia 'rf' window subject [during ECRH use] to dielectric and thermal-conductivity damage and strength changes, as induced by fast neutrons, involves reductions in service lifetimes by orders of magnitude.

9. SUPERCONDUCTING MAGNET MATERIALS 217

No contributions received this period.