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Alloy Development for Irradiation Performance

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Microstructural studies indicated several possible causes for the low ductility observed in the Path B alloys. Precipitation of helium bubbles at grain boundaries was observed for all alloy conditions. Helium bubbles at grain boundaries could cause a reduction of the grain boundary cohesive energy and could also serve as potential crack nucleation sites during deformation. Other precipitates, which are known to cause a reduction in grain boundary strength were also observed. For example, cavities formed at precipitate/grain-boundary interfaces in cold worked and aged alloy B1; a layer of γ′ completely coated grain boundaries in cold worked alloy B1; and η-phase plates were aligned in the grain boundary region' in cold worked and aged alloy B4. These features weaken the grain boundaries and diminish their ability to deform. Relative to the weakened boundary, the mztrix is quite strong, being strengthened by the formtion of γ′ or γ′/γ″ precipitates, radiation-induced faulted loops, and a high density of helium bubbles. Due to the limited deformation tolerance of the grain boundaries, failure wilt be initiated there before matrix deformation can relax local stress concentrations at high temperatures. 4 single principal mechanism to explain the low ductility phenomena observed cannot be selected a the basis of the results of the microstructural studies.

Path B alloys in their current form will not provide adequate ductility for first wall application at high temperatures.

Creep/stress-rupture tests were performed on sheet specimens of the three Path C vanadium Scoping Alloys in the temperature mnge 650 to 800°C. These specimens had been intentionally contaminated with nominal additions of 600 and 1200 wppm oxygen by controlled gas-metal reactions. The effects of oxygen additions on the creep behavior of the vanadium alloys, over the limited range of stress-temperature conditons examined, did not appear to be significant.

The microstructure of gas tungsten arc (GTA) welds of a $(Ni,Fe)_3(V,Ti)$ LRO alloy has been investigated. Crack-free welds were produced in which the heat-affected zone (HAZ) and fusion zone were disordered and softened. A

Compatibility tests were wnducted with several ferritic and austenitic steels at 700 and 755 K to study the corrosion behavior in flowing lithium, and fatigue tests were performed with Type 316 stainless steel in lithium at 755 K. The results indicate that an increase in the nitrogen content in lithium increases the dissolution rate, whereas the depth of internal penetration is not affected significantly. The dissolution rate of ferritic steels is an order of magnitude lower than for the austenitic stainless steel. The austenitic steels develop a very porous ferrite layer, whereas the ferritic steels exhibit little or no penetration. For the austenitic stainless steels, depth of internal penetration increases with time and the penetration mtes at 755 K mnge from 50 to 180 μm/year. Preliminary data on Type 316 stainless steel yield similar penetration mtes at 700 and 755 K. The fatigue life of annealed Type 316 stainless steel in lithium at 755 K is a factor of 3 to 8 greater than in air.

Specimens of type 316 stainless steel were exposed to static pure lead for 1000 and 3000 h at 400, 500, and 600°C, respectively. Weight tosses measured in these tests were compared with those measured in similar tests with Pb–17 at. % Li. The data showed that the addition of 17 at. % Li to lead has some effect on its dissolution behavior relative to type 316 stainless steel; however, the weight losses in both the lead-lithium and pure lead melts were much larger than in pure lithium. Preliminary results from compositional analyses of type 316 stainless steel exposed to static Pb–17 at. % Li showed surface depletion of nickel at 500°C.

The compatibility of ferritic and austenitic steels with Li_2O pellets has been investigated at 823 K (550°C) in flowing helium containing 93 ppm H_2O and 1 ppm H_2. The results indicate that hoth steels develop an iron-rich outer scale and a chromium-rich subscale. The reaction rates for ferritic and austenitic steels are comparable and yield a value of –85 μm/year for penetration rate. The Li_2O pellets exposed with the various alloys lose weight. The weight loss follows a parabolic law, predicting a value of ~4.8%/year.