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Interactive Influence on Void Swelling in 300 Series Stainless Steels of Coupled
Gradients in Temperature and DPA Rate

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Recently, experimental evidence has accumulated that demonstrates that the dependence of swelling in austenitic steels on dpa rate has been strongly underestimated. In development of swelling correlations for both fusion and fission reactor applications the dpa rate is frequently but inadvertently incorporated into the temperature dependence. This inability to separate the separate dependencies of dpa rate and temperature is closely associated with the coupling of gradients in neutron flux-spectra and irradiation temperature along the axial length of components, especially for relatively small cores.

In order to demonstrate the separate action of dpa rate and temperature, previously unpublished swelling data are presented from hexagonal ducts, fuel pins and pressurized tubes irradiated in EBR-II, all possessing both axial and radial gradients in dpa rate. Annealed AISI 304 components were chosen to avoid complications of precipitation found in other alloys such as AISI 316 or PCA. Since this steel never develops multiple-peak swelling behavior and experiences very little precipitation at high dpa rates, it use in this effort is ideal for separation of environmental variables.

It is demonstrated that the transient regime of void selling is increased by increasing dpa rate and by decreasing temperature. It is also shown that the combined effect of dpa rate and temperature distribution along the length of any given structural component produces a well-defined, scatter-free "swelling loop" vs. dpa that uniquely allows estimation and separation of the separate dependencies of swelling on temperature and dpa rate. One consequence of the derived flux dependence is that components subject to a dpa rate gradient in general suffer much less distortion than predicted by equations that do not explicitly incorporate a dependence on dpa rate. It is also shown that over a wide range of irradiation conditions the terminal steady-state swelling rate of AISI 304 is consistent with the ∼1%/dpa characteristic of austenitic stainless steels. The insights developed in this effort are now being applied to more complex alloys envisioned as candidates for fusion first-wall application.

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