COMPARISON OF SWELLING AND IRRADIATION CREEP BEHAVIOR OF FCC-AUSTENITIC AND BCC-FERRITIC/MARTENSITIC ALLOYS AT HIGH NEUTRON EXPOSURE - F. A. Garner (Pacific Northwest National Laboratory)*, M. B. Toloczko (Washington State University), and B. H. Sencer (New Mexico Tech)

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EXTENDED ABSTRACT

It is well-known that ferritic and ferritic/martensitic steels develop much less swelling than austenitic steels during neutron or charged particle irradiation. The prevailing assumption is usually that the steady-state swelling rate of bcc steels is inherently much lower than that of fcc steels, at least a factor of ten or more. It is shown in this paper that this perception is incorrect, with bcc steels having steady-state swelling rates perhaps only a factor of two lower. The creep compliance of the two types of alloys also differs only by a factor of about two.

This misperception arose from a dose assignment error made ~15 years ago, where both Fe-Cr-Ni ternary austenitic alloys and Fe-Cr binary ferritic alloys in one important EBR-II experiment were assigned dpa exposure levels that were too large for the lowest temperature capsules. When the error was recently corrected, it was found that an apparent low-temperature tendency toward saturation of swelling in Fe-Cr-Ni alloys disappeared, and that the very low steady-state swelling rate of Fe-Cr binaries was strongly underestimated and still may not have been attained at the termination of the experiment. Figure 1 presents the corrected EBR-II data. Recent Russian data on the swelling of cold-worked iron and Fe-Cr alloys tends to confirm a possible steady-state swelling rate approaching ~0.5%/dpa.

The lower swelling observed in both model and commercial bcc steels is shown in this paper to be a consequence of much longer transient regimes prior to the onset of steady-state swelling. Several other commonly held perceptions concerning the swelling of both bcc and fcc steels are examined in this paper and also shown to require revision. These involve the effect of cold-work on swelling and the extent of the temperature regime of swelling.

It also appears that the use of well-controlled in-reactor materials tests that employ active temperature control in FFTF-MOTA tend to yield significantly lower values of void swelling compared to that obtained under more representative conditions typical of actual reactor operation in EBR-II. Not only was this observed in fcc Fe-Cr-Ni alloys but also in Fe-Cr binary alloys, as shown in Figure 2.

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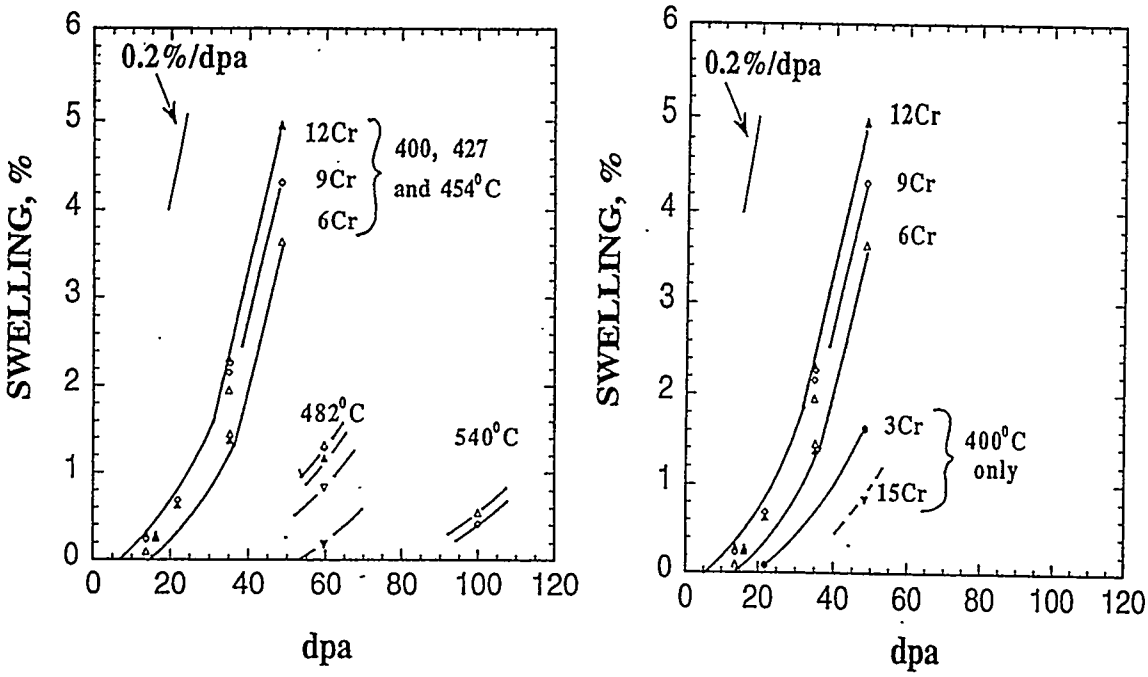

Figure 1. Corrected compilation of Fe-Cr swelling data from an early EBR-II experiment, showing that the primary influence of both chromium content and temperature lies in the duration of the transient regime. This behavior was also seen in the fcc Fe-Cr-Ni ternary alloys irradiated in the same capsules.

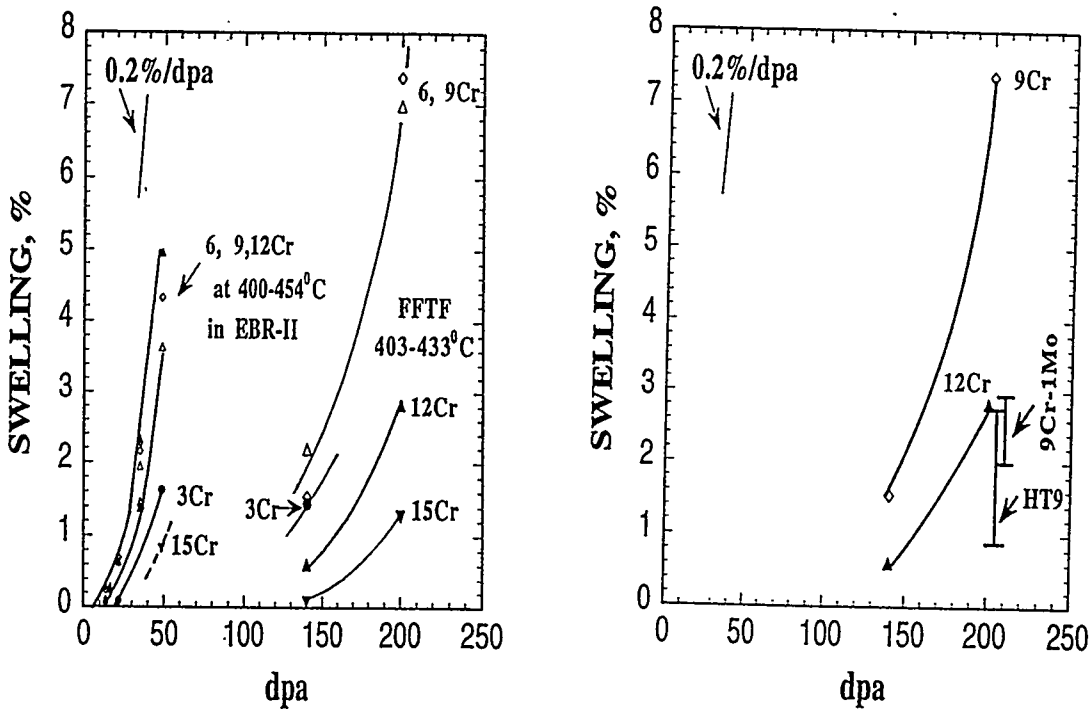

Figure 2. Comparison of EBR-II and FFTF-MOTA data for identical Fe-Cr alloys. Note that HT9 and 9Cr-1Mo irradiated in FFTF-MOTA appear to have only slightly longer transient regimes of swelling.