April 24, 2001

MEMORANDUM TO: William H. Bateman, Chief
Materials and Chemical Engineering Branch
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Office of Nuclear Reactor Regulation

FROM: Nilesh C. Chokshi, Chief **/RA/ by Nilesh C. Chokshi**
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SUBJECT: ARGONNE NATIONAL LABORATORY REPORT ON NICKEL ALLOY CRACKING NUREG/CR-6721

Attached is a recent NUREG report, "Effects of Alloy Chemistry, Cold Work, and Water Chemistry on Corrosion Fatigue and Stress Corrosion Cracking of Nickel Alloys and Welds," by O.K. Chopra, W. K. Soppet, and W.J. Shack (Argonne National Laboratory).

The attached report is a summary of the state of crack growth rate measurements for these materials under both cyclic (fatigue) and constant loadings (SCC) which the authors regard as relevant to the V.C. Summer problem, the Oconee problem, and related issues.

A brief summary of key results follows:

1. The fatigue crack growth rates (CGRs) of Alloy 600 are enhanced in high dissolved oxygen (DO) water relative to an air environment. Also, in high-DO water, the fatigue CGRs at 320°C are comparable to those at 289°C, and the environmental enhancement does not appear to depend on carbon content or heat treatment.

2. For low-DO water, the environmental enhancement of fatigue CGRs for Alloy 600 does seem to depend on material conditions such as yield strength and grain boundary carbide coverage. Materials with high yield strength and/or low grain boundary carbide coverage exhibit enhanced fatigue CGRs.

3. For Alloy 600, correlations have been developed for estimating the enhancement of fatigue CGRs in LWR environments relative to CGRs in air under the same loading conditions.

4. For Alloy 690, the data suggest some enhancement of CGRs in high-DO water. Limited data indicate no environmental effects on CGRs in low-DO water. However, the existing database is small and additional work is needed in this area.

5. Fatigue CGRs of Alloy 82 and 182 welds are enhanced in PWR water relative to the air environment. The results show significant scatter, but the CGRs for the welds may be up to a factor of 10 higher than those for Alloy 600 in air.

6. In a BWR environment with normal water chemistry (NMC), the fatigue CGRs of Alloy 182 weld are enhanced relative to those of Alloy 600 in air. Hydrogen water chemistry (HWC) has a beneficial effect on CGRs; they are decreased by a factor of 5-10 when the DO level is decreased under HWC conditions.

7. For the constant load case (SCC), the data indicate enhanced SCC susceptibility for Alloy 82 and 182 welds in comparison with Alloy 600. SCC CGRs for welds exhibit significant scatter with most reported SCC CGRs being maximum values obtained from the maximum estimates of crack length. Average CGRs are approximately a factor of 2 lower than the maximum values.

8. The SCC data have been compared with correlations developed from available SCC models. Through appropriate selection of constants in the models, the predicted CGRs from the correlations are reasonably consistent with the available data for SCC in LWR environments.

Argonne is reorganizing its plan of Ni alloy and weldment cracking research so as to make it more immediately responsive to current NRC needs. The results of this ongoing work will be contained in the Argonne monthly and semiannual reports, both of which are regularly distributed to your staff.

If you have any questions please contact Michael McNeil of my staff on 415-6007, or by email: mbm@nrc.gov for further information on this report.

Attachment: As stated

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