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Susceptibility of Irradiated Steels to Hydrogen Embrittlement

An investigation was conducted to determine whether irradiated pressure-vessel steels 4340 and 212-B could become susceptible to hydrogen embrittlement, and if these irradiated structures would then be susceptible to catastrophic failure. Knowledge of the effect of irradiation on various types of steel is extremely important for reactor safety.

The results of the investigation are contained in the report, *Hydrogen Embrittlement in Irradiated Steels,* by A. D. Rossin, ANL-7266, February 1967, Argonne National Laboratory, Argonne, Illinois. This report completely presents the very specialized area of hydrogen embrittlement of 4340 and 212-B steels. Background information, experimental procedures, testing results, and possibilities for future work are included.

Two very different steels were examined. A high-strength steel, quenched and tempered 4340, was chosen because its behavior when charged with hydrogen is well known and documented. It was irradiated, then hydrogenated and tested in a manner which had previously revealed catastrophic embrittlement.

Steel 212-B was chosen because of its use as a vessel material in a number of pressurized- and boiling-water reactors. Further, fully documented material was available. Samples of 212-B were exposed to an irradiation dose large enough to raise its ductile-brittle transition temperature well above room temperature to cause a substantial increase in its yield and tensile strength. It was then hydrogenated and tested in the manner that results in catastrophic failure in 4340.

Hydrogen-charging conditions which completely embrittled 4340 high-strength steel had negligible effect on 212-B pressure vessel steel in tensile and delayed-failure tests. Much higher hydrogen charges reduced the notch-tensile strength slightly. Delayed failure was observed only at stresses above 90% of the notch-tensile strength of the hydrogenated 212-B. Tests on 212-B, which had been irradiated to give a 35% increase in strength and an NDT temperature shift of 94°C, showed the same relationship between delayed-failure limits and notch-tensile strength as that observed without irradiation.

Catastrophic embrittlement due to hydrogen was not observed in 212-B, even for irradiated material that had been charged to produce high hydrogen content. Therefore, catastrophic hydrogen embrittlement of a well-designed nuclear-reactor pressure vessel is not probable.

The notch-tensile strength of 4340 steel was reduced by irradiation, although the tensile strength increased. Catastrophic delayed failure still occurred, but the sensitivity to hydrogen was slightly reduced.

Notes:

1. This report is available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151; price $3.00 (microfiche copies, $0.65).
2. Inquiries concerning this innovation may be directed to:

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Patent status:

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