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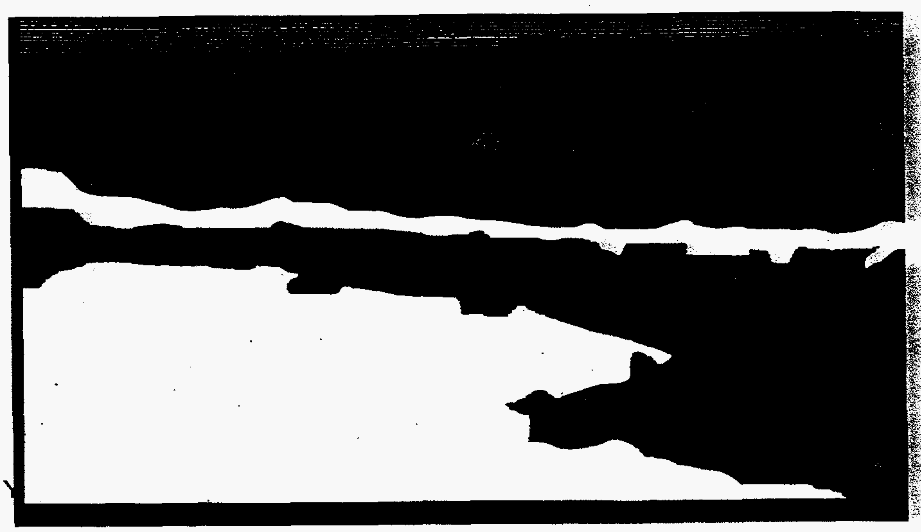

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Qualification Tests of Materials for Spallation Neutron Sources

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Several existing and planned facilities, worldwide, use protons in the 650 - 2000 MeV energy range to produce neutrons by spallation reactions. Research applications such as neutron scattering are pursued at the Intense Proton Neutron Source (IPNS) at Argonne National Laboratory, the ISIS facility at Rutherford-Appleton Laboratory, Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory, Swiss Neutron Source (SINQ) at the Paul Scherrer Institute, and others.

There are new facilities in the planning stage that utilize spallation neutrons in the area of Accelerator-Based Transmutation Technologies (ADTT) including designs for transmuting radioactive waste (ATW), power production, and tritium production (APT). There are also initiatives for new research applications including the National Spallation Source (NSS) at Oak Ridge National Laboratory a proposal for a Long Pulse Spallation Source (LPSS) at Los Alamos, and proposals for several different spallation neutron sources around the world.

Operation of advanced spallation neutron sources will require high reliability and a nine month per year operating cycle. Materials that comprise the target and blanket structures will be exposed to high-energy proton fluences of 10^{25} -10^{26} /m^2 per year. Some components will also be exposed to a charged particle plus spallation neutron fluence of $> 10^{26}$ /m^2 per year.

Development of radiation-resistant and radiation-tolerant materials for use in fission reactors has received substantial attention over the past 50 years. More recently, the fusion reactor initiatives have required additional materials radiation damage effects studies since here the neutron energy is higher, 14 MeV opposed to an average of about 1 MeV for a typical power reactor. The information obtained in these programs is being applied to the design of spallation neutron sources.

The target, blanket, and moderator components are exposed to particle radiation with energy up to 1.3 GeV. Only a limited data base is available for materials applications in this environment. Because of experience at accelerators such as at the Los Alamos Meson Physics Facility, now Los Alamos Neutron Scattering Center (LANSCE), phenomenological evidence indicating good material performance of a limited number of structural materials and target materials, for adequate operating times, is available. Determination of design data such as strength and ductility has been limited to very low dose experiments.

As the particle energy increases to above 20 MeV or so a major new variable becomes important; copious transmutation products are generated and enter metal alloy systems as impurities. Helium atoms produced in a metal lattice been found, by the fusion reactor community, to have a major effect on materials properties. Neutrons with energy of 14 MeV such as are present at fusion reactors produce helium through an (n,α) reaction while 200 - 1300 MeV protons produce about 100 times more helium per particle through spallation reactions. The atom recoil energies following a spallation reaction are also higher that that experienced in fission and fusion environments, leading to high energy cascade and sub-cascade cluster formation.

Corrosion-related phenomena have been studied at fission reactor installations and difficulties have largely been solved. Less is known about cooling systems at accelerators; difficulties have been encountered but a basic understanding of the governing conditions is not known. A synergism between charged particle interactions at metal surfaces in contact with water containing radiation-produced radiolysis products is expected to be the driving force for corrosion.

The APT project is sponsoring an extensive materials qualification program that includes irradiations in the proton beam and neutron field available at the Los Alamos Spallation Radiation Damage Facility (LASREF) at LANSCE. A number of candidate materials will be exposed to prototypic spallation producing particle radiation. Studies of corrosion-related phenomena and the mitigation of these effects will also be accomplished. Extensive testing of the effect of a spallation environment on the mechanical properties of materials is planned. In parallel, calculations of radiation damage parameters and transmutation product generation will be completed using the available high-energy Monte Carlo-based transport codes. Radiations will begin in August 1996 and are scheduled for completion in June 1997. This work enjoys the close collaboration of several laboratories in the United States and Europe; extensive post-irradiation measurements of radiation damage effects will be conducted, in parallel, at several laboratories.