EVALUATION OF ZIRCONIUM-IRON-RHENIUM ALLOYS AS SURROGATES FOR A TECHNETIUM ALLOY WASTE FORM

A Thesis

by

PAUL AARON MEWS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2007

Major Subject: Nuclear Engineering

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Approved by:

Chair of Committee,	Sean M. McDeavitt
Committee Members,	William S. Charlton
	Richard B. Griffin
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ABSTRACT

Evaluation of Zirconium-Iron-Rhenium Alloys as Surrogates for a Technetium Alloy Waste Form. (December 2007)

Paul Aaron Mews, B.S., Purdue University

Chair of Advisory Committee: Dr. Sean M. McDeavitt

Stainless steel – zirconium alloys were developed by the US Department of Energy Laboratories as metallic waste forms for noble metal fission products. This thesis evaluates iron–zirconium–rhenium alloys to establish a technical basis for using metal waste form alloys for technetium-99 immobilization. Rhenium is used as a surrogate for Tc-99 since Tc is not naturally available and Re is metallurgically similar to Tc.

The iron-zirconium system has two eutectic compositions, Fe-15 wt % Zr and Zr-16 wt% Fe. Ten test samples were successfully cast in yttrium oxide crucibles at 1600°C, half near each eutectic composition, with Re amounts varying from 2.5 to 12.5 weight percent.

A scanning electron microscope (SEM) with energy dispersive X-ray spectroscopy (EDS) capability was employed to determine the phase structure and phase composition of each sample. Iron rich samples were found to form up to three phases, with the rhenium content favoring the intermetallic phases: 1) an Fe solid solution phase, 2) an $FeZr_2$-type intermetallic with 11 wt % or less Re, and 3) a second intermetallic

with about 18 wt % Re. Zirconium rich samples formed as many as five distinct phases: 1) a Zr solid solution phase, 2) a Zr_3Fe-type intermetallic with as much as 13 wt% Re, 3) a rhenium-zirconium intermetallic, 4) another Fe-Zr intermetallic with very little Re, and 5) a Fe-Re intermetallic.

Potentiostatic and potentiodynamic electrochemical tests were performed using sulfuric acid to evaluate the corrosion resistance of each sample. These tests found that the zirconium rich samples were very corrosion resistant but became increasingly susceptible at higher rhenium concentrations. The iron rich samples were not very resistant to corrosion under the test conditions; there was no notable trend in corrosion behavior related to the introduction of rhenium.

DEDICATION

This thesis is dedicated to my parents, Gary and Amy. Their efforts to my education twenty years ago at age three made possible my academic accomplishments at age twenty-three.

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Many thanks to Dr. Richard Griffin of Texas A&M for his guidance, education, and material aid concerning electrochemical corrosion. He provided the hardware and computer software that made the electrochemical testing possible.

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