Transmutation of Technetium in the Petten High Flux Reactor:
A Comparison of Measurements and Calculations

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Abstract — Within the frame of the EFTTRA (Experimental Feasibility of Targets for TRA
smutation) cooperation, rods of 99 Tc metal are irradiated in the Petten High Flux Reactor for 193 effective full power
days, during which ~6% of the 99 Tc is transmuted to the stable 100 Ru. The radial and axial ruthenium
distributions in one of the rods are measured by electron probe microanalysis. In the radial direction,
the ruthenium concentration strongly increases in the outer rim of the sample, while the axial distribution
shows little variation. The average ruthenium concentration, as measured by isotope dilution mass spec
rometry, is (6.4 ± 0.2)% at 5 mm from the bottom of the rod and (6.1 ± 0.2)% at 5 mm from the top. The
ruthenium concentrations calculated by the KENO three-dimensional Monte Carlo code, 6.1% at 5 mm
from the bottom of the rod and 5.7% at 5 mm from the top, are in reasonable agreement with the measured
ones. However, the calculated radial distribution of the ruthenium concentration does not agree with the
measurements. The radial profile calculated by the MCNP Monte Carlo code, which uses a pointwise
cross-section library, agrees much better with the measurements.

INTRODUCTION

The long-lived fission product 99 Tc is among the most
important nuclides that dominate the beta activity of spent
fuel after a hundred thousand years. Because of its high
solubility in (ground)water, technetium is easily trans-
ported to the biosphere once it is released from the deep-
geological waste repository. To reduce the dose risks to
future generations, technetium is one of the fission prod-
ucts that should be partitioned from the spent fuel and
treated separately, e.g., transmuted in nuclear reactors or
conditioned by chemical immobilization.

In 1992, the EFTTRA (Experimental Feasibility of
Targets for TRA
smutation) collaboration was founded
between Commissariat à l’Energie Atomique (CEA),
Netherlands Energy Research Foundation ECN, Electric-
ité de France, Forschungszentrum Karlsruhe, Institute for
Advanced Materials, and the Institute for Transuranium
Elements (ITU), with the aim to investigate experimen-
tally the behavior of targets during irradiation in fast and
thermal nuclear reactors and to demonstrate the applica-
ability of scenarios for the transmutation of long-lived fis-
sion products and minor actinides.1,2 One of the first
experiments of EFTTRA has been the irradiation of six
metallic technetium rods in the Petten thermal High Flux
Reactor (HFR). During this irradiation, the long-lived 99 Tc
is transmuted to the stable 100 Ru. This paper describes
the comparison of measured and calculated ruthenium
concentrations and profiles obtained from postirradia-
tion examinations (PIEs) and three-dimensional Monte
Carlo calculations, respectively.

TARGET CHARACTERIZATION

The technetium sample was a 4.8-mm-diam, 25-mm-
long rod of technetium metal, which was fabricated at
the ITU in Karlsruhe, Germany, as part of a series of six.
Details of the fabrication method are described in Ref. 3.
The density was higher than 99.9% of the theoretical den-
sity. Analysis by glow-discharge mass spectrometry
showed that the ruthenium concentration in the metal was
< 1 part per million.

In the EFTTRA-T1 irradiation experiment, three tech-
etium targets were irradiated, each containing two rods,