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Title: Analysis Capabilities for Plutonium-238 Programs

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NMT-9

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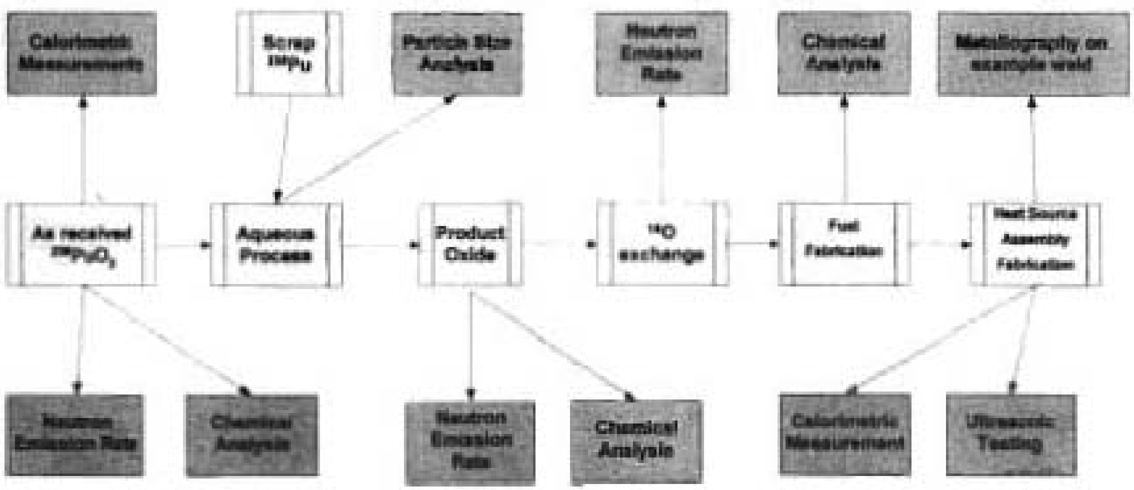
Introduction

Plutonium-238 Group (NMT-9) at Los Alamos Plutonium Facility has full capabilities to recover and purify $^{238}PuO_2$ from scrap and aged fuels (*aqueous scrap recovery*), to fabricate oxides into fuel pellets, and to assemble into general purpose heat source (GPHS). An overview of analysis capabilities that support ^{238}Pu programs are presented here.



^{238}Pu Heat Source Fabrication

Impact Testing

Chemical Analysis of ^{238}Pu Materials

Chemical data of ^{238}Pu materials (feed oxide, purified oxides, granular ^{238}Pu, and process solutions) provide necessary baseline parameters and measures for process control, material control and accountability, waste disposal, and product certifications.

Analytical Chemistry Group provides information on plutonium assay, actinide analysis (^{234}U, ^{241}Am, ^{237}Np, and ^{236}Pu), Pu isotopic composition, and non-actinide cationic and anionic impurities.

^{238}Pu group has several in-line analyses capabilities to provide real-time chemical information. These include SILAC (Solution In-Line Alpha Counter) and PPM (Plutonium Process Monitoring) System.

SME: Amy Wong of NMT-9 and Analytical Chemistry Group

Chemical Analysis-Methodology

<u>Plutonium assay</u>: utilize Pu(III) visible spectrometry

<u>Actinide analysis</u>: Radiochemical methods

- ^{241}Am by high resolution gamma-ray spectroscopy
- ^{237}Np and ^{234}U by ion-exchange, gross alpha & alpha spectroscopy
- ^{236}Pu by alpha spectroscopy
- thorium by inductively coupled plasma mass spectrometry (ICP-MS)

<u>Isotopic composition</u>: thermal ionization mass spectrometry

<u>Non-actinide cationic impurities</u>: direct-current arc (DC Arc)

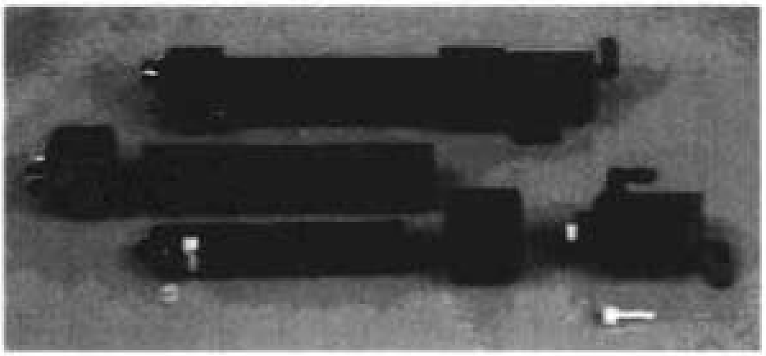
(Al, B, Be, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, Pb, Si, Sn, Zn)

<u>Anionic impurities</u>: phosphorus by ICP-MS

SME: Amy Wong of NMT-9 and Analytical Chemistry Group

In-Line Chemical Monitoring Systems

SILAC

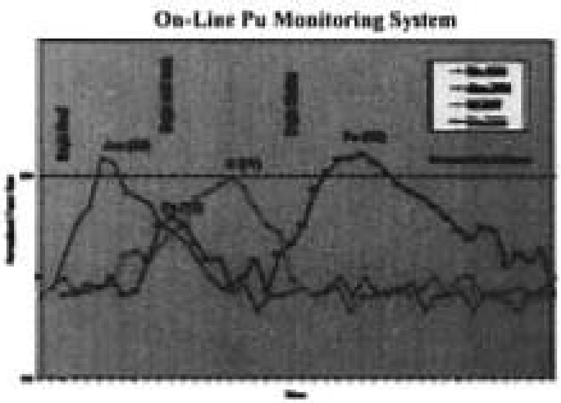


Provide alpha concentration in line without sample-out for analysis

- **Semi-quantitative analysis**
- **Large dynamic range for Pu detection: ~0.1 to 6000 mCi/L**

Monitor ^{241}Am, ^{237}U, ^{239}Pu, ^{238}Pu, and ^{241}Pu gamma rays during aqueous scrap recovery process. Provide real-time trend plot of loading, washing and elution profiles.

Provide information for process monitoring and improvement. Help to minimize solution volume and waste generation.



Plutonium Process Monitoring (PPM) System

SME: Amy Wong

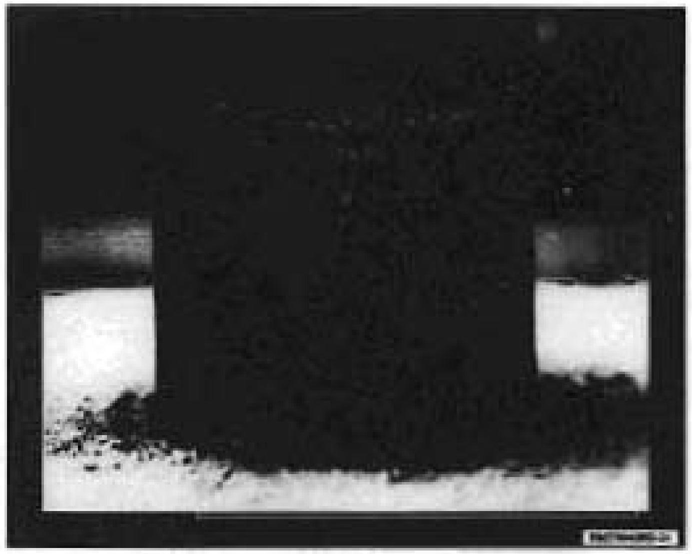
Calorimetric Measurements

^{238}Pu, $t_{1/2}$ = 87.74 years

Power output = 0.567 W/g

Two types of calorimeters used in ^{238}Pu laboratory:

- Low wattage, 0 to 5 W ± 0.003 W
- High wattage, 0 to 200 W ± 0.5 W



Calorimetry is used to verify the amount of special nuclear materials in incoming fuel materials, outgoing scrap, and finished heat source assemblies.

SME: NMT-4/NIS-5 Calorimetric Measurement Team

Neutron Emission Rate (NER) Measurements

Spontaneous fission of ^{238}Pu produces ~ 2220 n/s/g of PuO_2 (at 81% of ^{238}Pu). Energetic alpha particles react with light isotopes such as ^{17}O, ^{18}O, ^{19}F in $^{238}PuO_2$ producing additions of 5000 to 20,000 n/s/g via (alpha, n) reactions.

The neutron emission rate is measured in a thermal neutron counter.

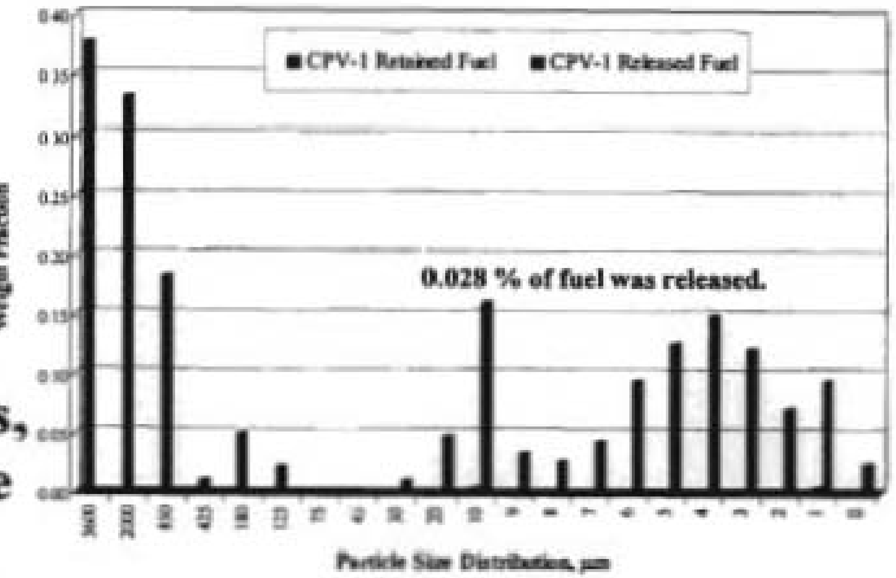
Neutron Emission Rate (n/s/g oxide)		
Fuel Fabrication	Fuel lots as received	^{16}O Exchanged
Lot # L620	18803	4459
Lot # L641	19884	9881
Aqueous Recovery	Oxalate Precipitated	Ion-Exchange Oxalate Precipitated
ASPPDTQ1	18671	12756
ASPPDTQ5	22558	13319

NER data for ^{238}Pu Materials in aqueous (IX and oxalate) and fuel fabrication lines (^{16}O)

SME: Jason Brock, John Brown, Gary Rinehart

Particle Size Analysis

Utilize Galai CIS-100 instrumentation to determine particle size distribution (0.5 to 600 micron) of ^{238}Pu and simulant fuels from impact testing (mainly fine particles, < 100 micron) and verify the particle size of milled ^{238}Pu oxide prior to dissolution for scrap recovery.



Particle size analysis of impact testing results (velocity at 55 m/s) of a hot- pressed simulant fuel (urania pellets)

SME: MaryAnn Reimus, Paul Moniz

Ultrasonic Test (UT)

UT is performed to examine the weld integrity of the $^{238}PuO_2$-fueled clad and simulant-fueled capsules. The cracks are not visible on the external surface of the weld, and if left undetected, could compromise the containment of $^{238}PuO_2$ in the unlikely event of an aborted launch or re-entry into the earth's atmosphere.

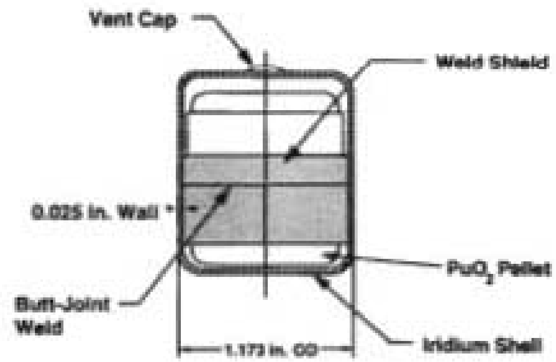
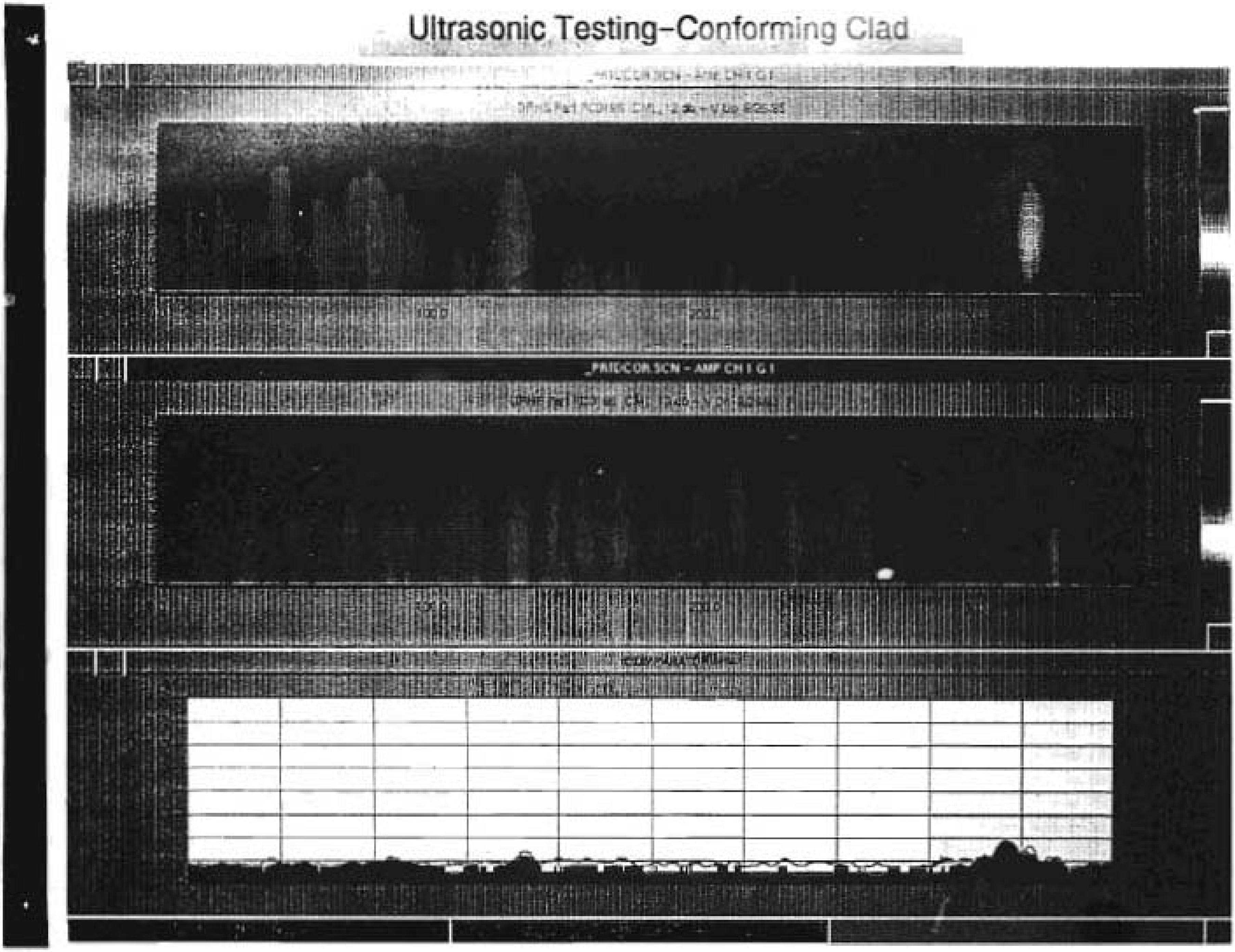


Figure 1. General-Purpose Heat Source (GPHS)

We use a 3.5-MHz transducer inspecting system with a 0.5-inch diameter and 1.5-inch spherical focus in water. The operator must have a minimum of an ASNT Level-I ultrasonic testing certification.

SME: MaryAnn Reimus, Paul Moniz

Ultrasonic Testing–Conforming Clad



5XO —

[redacted]

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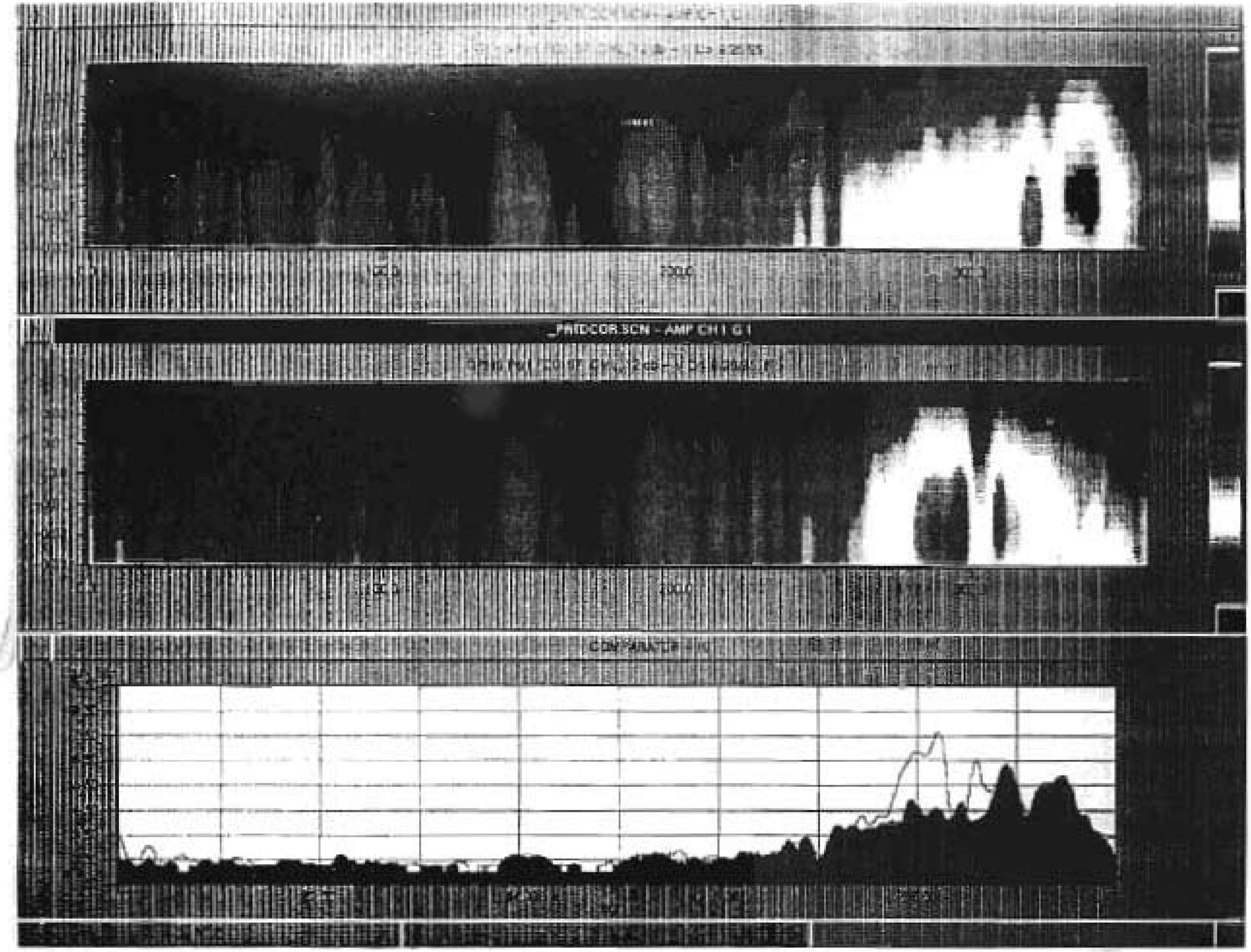
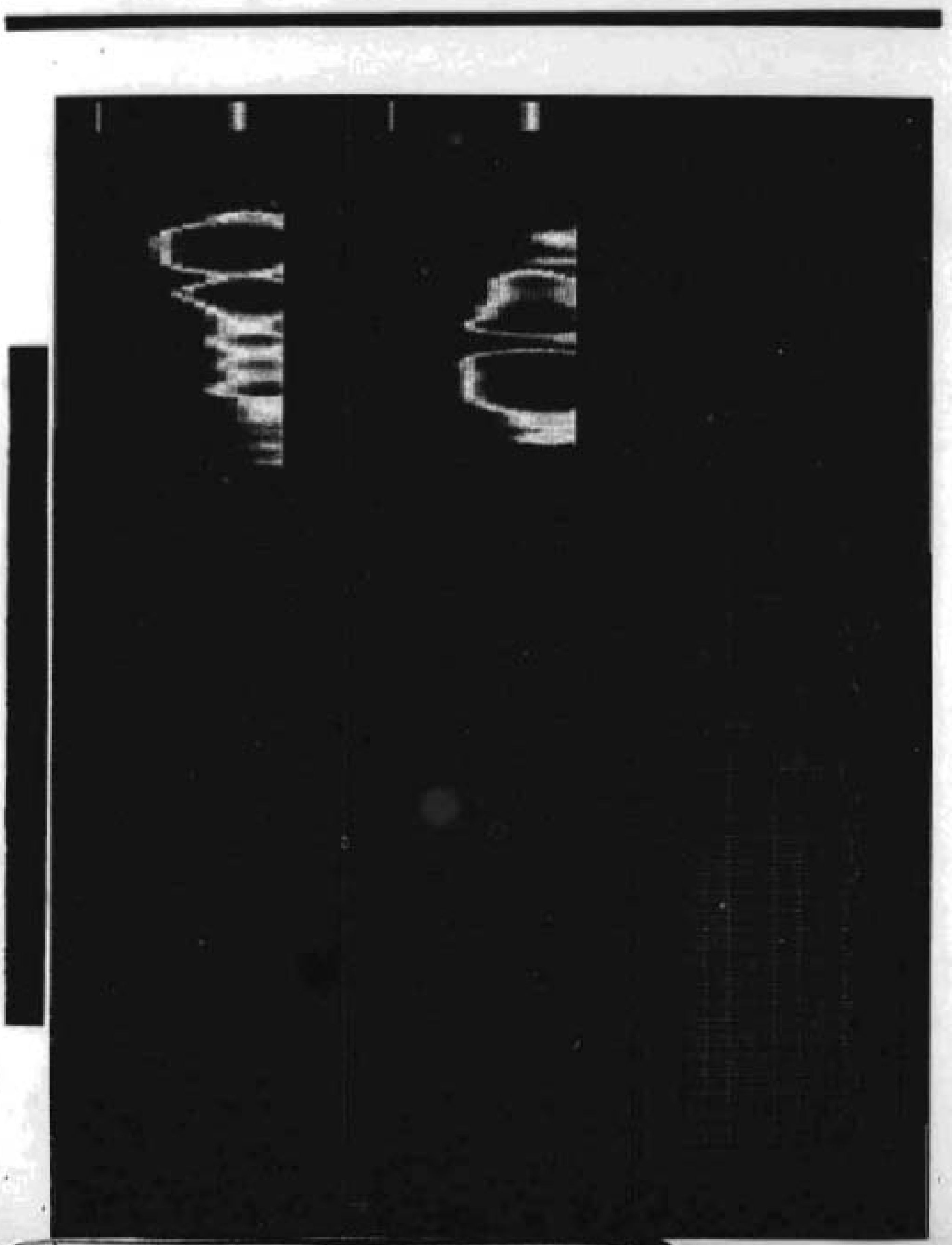
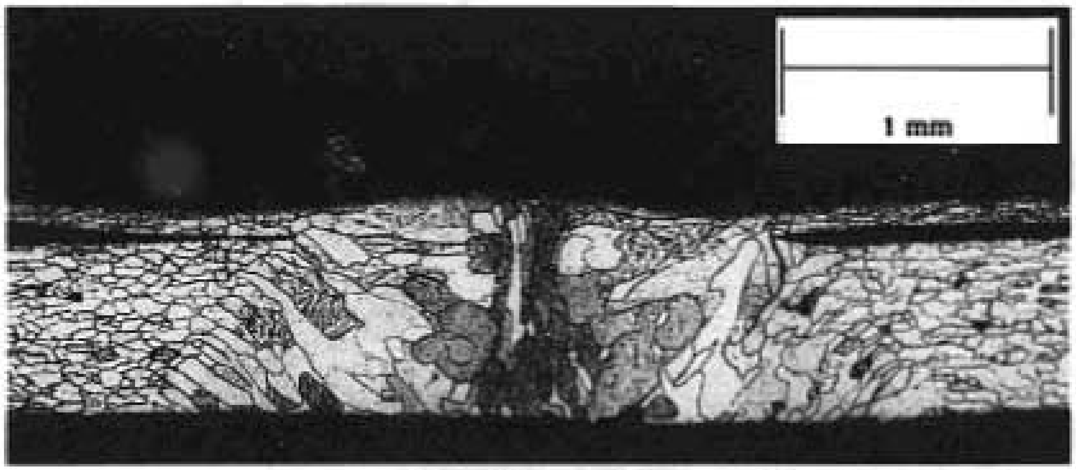
Ultrasonic Testing-Non-Conforming Clad





Metallography/Ceramography

Metallography/ceramography examinations are performed on test components recovered from impact tests of $^{238}PuO_2$-fueled and simulant-fueled clads. The microstructure of the GPHS clad material, girth welds, and samples of fuel pellets are also examined.



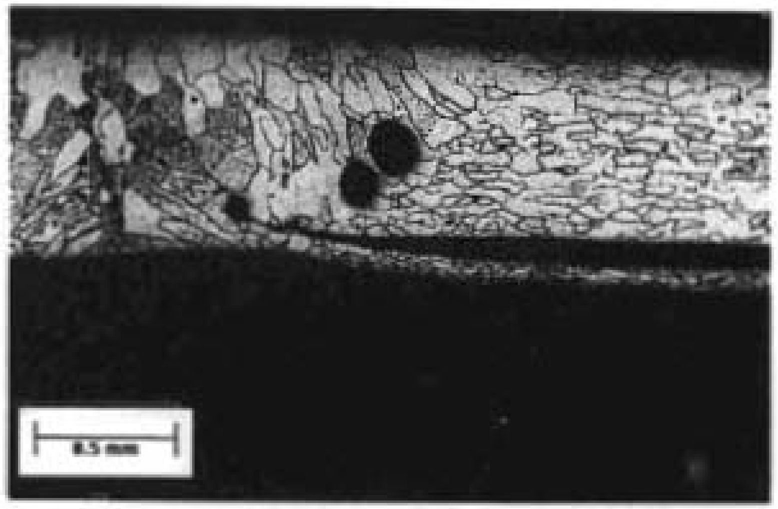
Metallography-conforming graph

SME: MaryAnn Reimus, Paul Moniz

Metallography/Ceramography

A LECO 300 metallograph with magnification range of 8 to 500 X is interfaced to the glovebox line through a unique hood extension that covers but does not enclose the metallographic stage.

The specimens are prepared using wafering saw, automated grinding, rough and fine polishing equipment.



Metallography-nonconforming graph

SME: MaryAnn Reimus, Paul Moniz

Acknowledgement

We thank Liz Foltyn, Tim George, and Kevin Ramsey for leading the past, current, and future ^{238}Pu programs at LANL.