Title
Non-Destructive Testing with Neutron Radiography at the UC Davis/ McClellan Nuclear Radiation Center

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Authors
Boussoufi, M.
Steingass, W.
Egbert, H.
et al.

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Non-Destructive Testing with Neutron Radiography

M. Boussoufi, W. Steingass, H. Egbert, H. Liu and R. Flocchini
The UCD/ MNRC (mainly a research facility) inherited NDT capabilities from the US Air Force.

The UCD MNRC was originally developed by the US Air Force to detect low-level corrosion and hidden defects in aircraft structures using neutron radiography.
The UCD/MNRC facility is equipped with a hexagonal grid, natural convection water cooled TRIGA reactor designed to operate at a nominal 2.0 MW steady state power as well as in pulse and square wave mode.

- Started operation in 1990 at the original 1 MW design
- Was upgraded to 2 MW in 1996
- The 2 MW modifications were part of a program to increase the MNRC’s irradiation capabilities, such as silicon doping, isotope production, and boron neutron capture therapy.
The reactor utilizes a specially designed annular graphite reflector accommodating four removable units to accept four separate source ends of beam tubes.
• These tangential beam tubes lead to four large investigation bays with neutron radiography capability.
• A live picture of the 4 beam inserts

To Bay 1

To Bay 2

To Bay 3

To Bay 4
The design basis for these beam tubes is to provide a path for primary thermal neutrons with minimum scattering and attenuation between the reflector inserts and radiography bays.
• Bay 1
• Bay 1 with an aircraft wing
- A cross-sectional view of 2 of the bays
• The beam tubes are made up of 3 sections:
  * The in-tank section
• Each beam tube ends with a bulk shield (personnel shield) and a separate boron-included fast shutter to initiate and complete a neutron exposure
  * The tank wall section
  * The bulk shielding section
Typical unperturbed beam parameters are summarized in the following:

<table>
<thead>
<tr>
<th>Facility</th>
<th>Thermal Flux (n/cm$^2$.sec)</th>
<th>Beam Aperture (inch)</th>
<th>L/D Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay 1</td>
<td>$\approx 4.2 \times 10^6$</td>
<td>1.40</td>
<td>200</td>
</tr>
<tr>
<td>Bay 2</td>
<td>$\approx 4.2 \times 10^6$</td>
<td>1.40</td>
<td>200</td>
</tr>
<tr>
<td>Bay 3</td>
<td>$\approx 5.6 \times 10^6$</td>
<td>1.54</td>
<td>175</td>
</tr>
<tr>
<td>Bay 4</td>
<td>$\approx 3.8 \times 10^5$</td>
<td>1.25 x 1.25</td>
<td>270</td>
</tr>
</tbody>
</table>

Bay 1

Bay 2

Bay 3

Bay 4

- 1.5 MW flux (n/cm$^2$.s)
- L/D
- Traditional film system and more recently computed radiography system utilizing reusable storage phosphor imaging plate (SPIP) are extensively used as 2D imaging recording media.
Bay 3 is designed with a charge coupled device (CCD) camera with system control hardware and software to perform 3D neutron tomography.
3D neutron tomography of a "3-way valve used to transfer direction of a fluid"
- Bay 4’s beam tube, different from the others, has an 11”-thick sapphire crystal filter to provide an even higher quality beam, i.e. much lower contamination from fast neutrons and gamma rays, for 2D neutron radiography.

**MATERIALS LIST**

1. GRAPHITE END PLUG
2. BISMUTH CRYSTAL
3. ALUMINUM SPACER
4. GRAPHITE SLEEVE WRAPPED WITH CADMIUM
5. ALUMINUM SLEEVE
6. SAPPHIRE CRYSTAL
7. BORON/CARBIDE APERATURE
8. Dy/In FOILS
9. LEAD/CADMIUM SLEEVE
10. GRAPHITE

**BAY 4 REFLECTOR INSERT**
UCD/ MNRC is committed to offering state-of-the-art neutron imaging experiences for research and non-destructive testing projects.

Our unique capabilities enable us to provide effective solutions to the customer’s needs.

A few of many services rendered are:

- Providing quality assurance of complicated titanium castings for aircraft.
- Looking for corrosion/corrosion effects in Aluminum and other materials that are penetrable by neutrons.
- Examine uniformity of corrosion-resistant coating.
If you need more information visit our website at:

http://mnrc.ucdavis.edu/

or send me an email at mboussoufi@ucdavis.edu