Protecting our Borders while Ensuring Radiation Safety

By
Dan A. Strellis

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The Mission

• Objectives of cargo inspection are to:
  – combat cargo crime
  – thwart terrorism

• Today’s threats:
  – nuclear weapons, explosives, chemical weapons, narcotics, “dirty” bombs, and manifest fraud

• Tools
  – trace detection systems
  – gamma, x-ray, and neutron interrogation systems
SAIC’s VACIS (Vehicle and Cargo Inspection System)¹

- 5 configurations (mobile, portal, rail, pallet, and relocatable)
- Over 200 systems used worldwide

¹www.saic.com/products/security
VACIS Technical Highlights

- 0.75-Ci $^{60}$Co or 1-Ci $^{137}$Cs
- Penetrability of 159-mm and 102-mm thick steel
- Scans 40-ft containers in ~30 seconds
VACIS Images

Illegal Drugs Located in Lead-Shielded Compartments

Rail VACIS in Laredo, Texas Revealing Stowaways
VACIS Rad Safety Protective Measures

• Fail-safe source shutter closes when power is lost
• Flashing beacons and audible alarms activated when source shutter is open
• Emergency Stop buttons on truck and in operator cab
• Integrity of source containment verified under severe explosive blast conditions (5000 lbs C4)
Eagle Operational Highlights

• Operating now in El Paso and Savannah
• Soon to be operating in Baltimore and Kingston, Jamaica
Eagle Technical Highlights

- 6 MeV LINAC x-ray source
- penetrability of 350 mm of steel
- scans 40-ft containers in 1 min
Miniature submarine inside a cargo container
“Big-fish-eating-a-little-fish” Image

Or

Aracor Eagle scanning a Rapiscan GARDS truck

NaI detectors

Lead shielding around $^{60}$Co source
Eagle Rad Safety Protective Measures

- When power is lost, x-ray source turns off
- Beacons, alarms, EMOs
- X-ray only on when
  1) there is an object inside the inspection tunnel
  2) Eagle is moving at the minimum inspection speed
- After inspection, x-ray turns off unless another object enters tunnel in a predetermined time
- Leaded glass used in cab windows to reduce dose to operator
AS&E’s ZBV (Z Backscatter Van)\textsuperscript{3}

\textsuperscript{3}www.as-e.com
ZBV Technical Highlights

- Primarily uses detection of Compton scattered x-rays to highlight organic materials
- Transmission image also available
ZBV Images

Cocaine hidden near rear window well and quarter panel

Stowaways hidden amongst cargo
Ancore PFNA at Ysleta Port of Entry in El Paso, Texas

www.ancore.com
PFNA Highlights

• Scan 75-ft semi-trucks in about 4 minutes
• Throughput of about 10 trucks per hour with 2 AGVs
• Neutron interrogation leads to material specificity. Unique signatures illuminated based on chemical elements present.
• Threat detection algorithms trigger on threat cases and display an automatic decision
• User interpretation of an image is eliminated!
The PFNA System Concept

Accelerator and neutron production system through D(d,n)³He reaction

Operator display

Scan arm and neutron collimator

Nal gamma detectors

Plastic scintillator neutron/gamma detectors

Truck being scanned

Signal processor
PFNA -- Scan Arm

ACI Scan Arm
Acoustic Test
October 1, 2003
PFNA data:
time-energy spectra of C4 explosive
Similar-looking items show different gamma-ray signatures (i.e. plastic v. leather purses, glass v. hard plastic, chemical agents v. water, explosive v. benign materials).
First Neutron Radiography Image of Truck in El Paso

Low Resolution, High Statistics Format

Water bottles

C4 simulant
Cargo Examples---Washer & Dryers

- PFNA can detect contraband hidden in scrap metal or machine goods.

Drugs

Explosives
PFNA Rad Safety Protective Measures

- Beacons, alarms, EMOs
- Building shielding and tunnel door shielding lowers dose to < 50 urem/hr
- Visual search of tunnel must be done before turning beam on
- Photosensor light beams on inside edge of tunnel shut beam off if broken
- Tunnel doors do not open unless beam is off
Regulations

- **10CFR20**
  - annual radiation dose equivalent for general public and non-radiation workers is 100 mrem
- **The US FDA**
  - cabinet x-ray system exposure rate limit is 0.5 mrem/hr at a distance of 5 cm from system
- **ICRP**
  - recommends that the dose to the public be limited to 100 mrem/yr
  - many countries have incorporated this standard
Exclusion Zones for General Public and non-Radiation Workers

- Annual dose limit of 100 mrem
- Based on 2000 hrs of operations a year
- Thus, average dose of 0.05 mrem/hr
- Examples:
  - VACIS EZ is 16-meters wide
  - Eagle EZ is 24-meters wide
  - PFNA EZ is inside tunnel and building
Stowaway Dose Levels for $^{60}$Co Systems

- $^{60}$Co version of VACIS
- Victoreen 450P gamma meter placed near human phantom
- Phantom standing near wall on source side during a normal-speed scan

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Stowaway Dose Levels for Eagle and PFNA

- PFNA dose on badge is neutron + gamma
- Phantom standing near wall on source side during a normal-speed scan

![Bar chart showing dose per scan (urem) for Eagle and PFNA systems with Victoreen 450P and Landauer OSL badges.](chart.png)
Number of Stowaway attempts allowed before exceeding the 100 mrem annual dose limit

<table>
<thead>
<tr>
<th>System</th>
<th>Number of stowaway attempts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile VACIS</td>
<td>6250</td>
</tr>
<tr>
<td>RL VACIS</td>
<td>5000</td>
</tr>
<tr>
<td>Rail VACIS</td>
<td>10000</td>
</tr>
<tr>
<td>Eagle</td>
<td>9</td>
</tr>
<tr>
<td>PFNA</td>
<td>3</td>
</tr>
</tbody>
</table>

PFNA operations requires a stowaway check of the first image before proceeding with further scans!
PFNA Stowaway Check

Gamma radiography

Neutron radiography
In Sum

• Many types of inspection systems currently being used
• Different radiation types, similar regulations
• All employ safeguards to ensure radiation safety to Operators, General Public, and Stowaways
• All systems certified by US BCBP must meet NRC and FDA radiation safety regulatory requirements