Learning Objectives

After completing this module, you should be able to:

- Define prohibited items
- Describe function of prohibited items detection systems
- Recognize types of detectors and their characteristics
- List the features of an effective prohibited items detection system relative to the DBT
IAEA Nuclear Security Series 13 (NSS-13)

- 4.25 Vehicles, persons and packages entering and leaving the protected area should be subject to search for detection and prevention of unauthorized access and of introduction of prohibited items or removal of nuclear material...
- 4.43 Instruments for the detection of nuclear material, metals, and explosives could be used for such searchers.

Prohibited Items

**Prohibited Item:** Any object or material that one is prohibited from bringing into or out of a security area

- Often a prohibited item is any device or material that can be used by an adversary to gain an advantage in an attempt to commit a malicious act
- Detection of prohibited items is important against insider threat
Purpose of Detection of Prohibited Items

**Systems**

<table>
<thead>
<tr>
<th>Allow Entry of</th>
<th>Prevent Entry of</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Authorized Material</td>
<td>- Weapons</td>
</tr>
<tr>
<td></td>
<td>- Explosives</td>
</tr>
<tr>
<td></td>
<td>- Other Contraband</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allow Exit of</th>
<th>Prevent Exit (theft) of</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Authorized Material</td>
<td>- Special Nuclear Material (SNM)</td>
</tr>
</tbody>
</table>

**Metal Detection**

- Weapons
- Tools
- Shielding
  - For radiological materials
- Bomb parts
  - Batteries
  - Wire
  - Metal shrapnel
- Cell phones
Factors Affecting Metal Detector Operation

- Environment
  - Metal objects near detector
    - Fork lifts, metal doors, metal cabinets
  - Electromagnetic sources
    - Radio transmitters
    - Fluorescent lights

- Performance
  - Type of metal
  - Orientation of threat
  - Location of threat relative to transmitter / receiver
  - Speed of threat passing through detector

Metal Detection Screening Techniques

- Portal metal detector
  - High throughput
  - Process needed to resolve alarms
  - Not easily portable

- Handheld metal detector
  - Lower throughput
  - Portable
  - Good for locating threats or resolving alarms
  - Training and procedures are important
Metal Detection Performance Testing

• Portal
  ▪ Test metal detectors for adequate detection of the worst-case threat item
    ▪ In the worst-case orientation, and
    ▪ At the worst-case location in the detector
  ▪ Test in the location where they are installed
  ▪ Test periodically to ensure their performance has not changed since installation

• Handheld
  ▪ Test metal detector for adequate detection of the smallest metal item
  ▪ Test procedures to assure they are adequate in detecting potential threats
    ▪ Periodically assess procedures and implementation of procedures

Package Search Systems

• Purpose
  ▪ Detect any contraband contained in packages
    ▪ Weapons
    ▪ Explosives
    ▪ Nuclear material
    ▪ Others

• Method
  ▪ Manual Search
  ▪ Active detection using X-ray energy (photons)
    ▪ Backscatter
    ▪ Dual-energy
    ▪ Computed Tomography
Manual Search

- Cost effective
- Low throughput
- Training is very important
- Potentially invasive, especially for personnel

Effectiveness of Backscatter

Transmission

Backscatter

Backscatter Portal
Dual Energy Package Search

- Certified 3-dimensional automated detection of explosives
- Large footprint
- Throughput 400+ packages per hour

Images courtesy of GE InVision, Inc.
Explosives Detection

- TNT \((\text{C}_7\text{H}_5\text{O}_6\text{N}_3)\)
- 2,4,6—trinitrotoluene
- PETN \((\text{C}_5\text{H}_8\text{O}_{12}\text{N}_4)\)
- Pentaerythritol tetranitrate
- Cyclonite = RDX \((\text{C}_3\text{H}_6\text{O}_6\text{N}_6)\)
- Ammonium nitrate \((\text{N}_2\text{H}_4\text{O}_3)\)
- Nitroglycerin \((\text{C}_3\text{H}_5\text{O}_9\text{N}_3)\)

Detection of Prohibited Items

Bulk vs. Trace Explosives

- **Bulk**
  - Detect a macroscopic amount (can see with eye) of explosive directly
  - Already discussed bulk imaging techniques
  - Manual search, Raman/Infrared, neutron activation

- **Trace**
  - Detect minute amounts of residual explosive material in the form of vapor or particles
  - Vapor pressure of an explosive affects detectability
  - Ion mobility spectrometry, canine, mass spectrometry, colorimetric
Detection Tools: Trace Explosives

- Detection of trace quantities of explosives can be performed on
  - **Personnel** by portal explosives detectors
  - **Packages** by desktop or handheld explosives detectors

Trace Sampling

- **Swipe sampling**: Wipe a sampling medium across the surface
  - Direct physical contact to pick up adsorbed particulates
  - Requires training
- **Vapor sampling**: Draw vapor into system concentrator
  - Explosives signature of vapor can be difficult to collect
Explosives Detection and Ion Mobility Spectrometer Performance Testing

- Right technology for right application
  - Nuisance and False Alarm Rate logs
  - Alarm resolution procedures
  - Probability of detection and confidence levels

- Throughput rate
  - Installation, calibration, maintenance
  - Performance testing
  - Operator interface
  - Operator interpretation
  - Standards
  - Clean-up time (after alarms)

Trace Detection Canine

- Method of choice for search applications
  - Highly mobile
  - Able to follow scent to its source

- Very fast and sensitive under optimal conditions; can detect any explosive

- Problematic for
  - Long-term, repetitive applications (dogs become tired)
  - Screening people (fear of dogs)
  - Can only detect material trained
    - For example, if a dog is trained on C4, the dog cannot detect pure RDX, which is main explosive in C4
Nuclear Radiation Detection Systems

**Purpose**
- Detect theft of Special Nuclear Materials (SNM)
- Discriminate among SNM, Radiation Dispersal Devices, and accidental contamination from natural, industrial, and medical radiation sources

**Principle of operation**
- Use detected gamma rays (and neutrons) to identify a threat
- Small distance between the source and detector is important

Examples of Radioactive Isotope Identification Devices

Photos: David Mercer, LANL
Radiation Detectors - Plastic

• Plastic
  ▪ Can be made very large
    • Widely used for screening
  ▪ Very inexpensive in comparison to other technologies
  ▪ Poor selectivity
    • Detects but does not classify radiation
    • Many false alerts due to radiopharmaceuticals and legitimate industrial radioactive materials
  ▪ Poor sensitivity to higher energy gamma radiation

Radiation Detectors – Sodium Iodide

• Sodium Iodide (NaI)
  ▪ Smaller but large enough to be usefully sensitive
    • Up to 10 × 5 × 40 cm pieces are in common use
  ▪ Relatively affordable
    • < $2,000 each
  ▪ Good selectivity
    • Can be used reliably for automated identification and classification of radiation sources
  ▪ Now being preferred for screening in most portal monitors
Radiation Detectors - Germanium

- High-purity Germanium (HPGe) - often used for secondary analysis
  - Most expensive – typically $30,000 to $120,000
  - Medium size – typically 100 cm³
  - Requires cryogenic cooling
    - Typically liquid nitrogen
  - Best selectivity by far
    - 30 times better than sodium iodide
- Because it is much more expensive, less sensitive (smaller in size), and requires cryogenic cooling, HPGe is often used for detailed analysis once a threat is suspected by a Radioactive Isotope Identification Device

Neutrons and SNM Detection

- Neutrons are not a specific indicator of Pu-239, Pu-240
  - There are many innocent sources of neutrons
    - For example, soil density gauges, moisture sensors, and oil well loggers
  - A higher count rate can result simply from moving a Radioactive Isotope Identification Device closer to a moderating source (heavy person, gasoline or water tank, etc.), which slows down more of the neutrons
  - False indication of neutrons also often results from energetic gamma rays interacting with the neutron detector material
Example: Sodium-Iodide Spectroscopic Portal Monitor in Use

Radiation Detection Performance Testing

- Strength of source
- Energy of source and shielding
- Distance from the detector to the source
  - Inverse square
- Time of sampling matters
  - Speed of vehicle or person
  - Throughput
Features of Effective System

• Designed to protect against types and amounts of weapons, tools, explosives per DBT
• Detects weapons and tools on entry
• Detects shielding and nuclear material on exit
• Designed with following considerations
  ▪ Humidity and temperature effects
  ▪ Throughput
  ▪ Alarm resolution procedures
  ▪ Nuisance alarm sources
    ▪ Explosives handled on site
    ▪ Heavy machinery near metal detector

Key Takeaways

• Detection of contraband (weapons, tools, explosives, SNM) is important for protection against insider threat
  ▪ Insiders may try to bring in contraband to conduct malicious act
  ▪ Insiders may try to exit with stolen contraband
• Detection techniques are generally specific to material
  ▪ Manual search (everything)
  ▪ Metal detection (weapons, tools)
  ▪ Package inspection (weapons, tools, explosives)
  ▪ Explosives detection
  ▪ Radiation detection (SNM)
• Consideration factors include threat, cost, throughput, and detection levels