U.S. Efforts to Advance the Safeguards "State-of-the-Art"

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Traditional Safeguards Approach

Goals

- Timely detection of diversion of a significant quantity of nuclear material
  - "Significant quantity" is defined as 8kg Pu, 25kg HEU, 8kg U-233
  - "Timely" is defined as:
    - 1 month for un-irradiated U, Pu, or MOX
    - 3 months for irradiated U or Pu
    - 12 months for indirect use materials (LEU, NU, Th)
- Detect undeclared nuclear materials and activities

Tools and Methods

- Material accountancy
- Material measurements: Destructive and Non-destructive Assay
- Containment/Surveillance: Cameras, seals, radiation detectors

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Non-Destructive Assay

- Active or passive interrogation of radiation from materials in containers
- Determine material type, quantity, and relative isotopic composition for verification purposes
- Allows for quick measurements, but with higher total measurement uncertainty than DA

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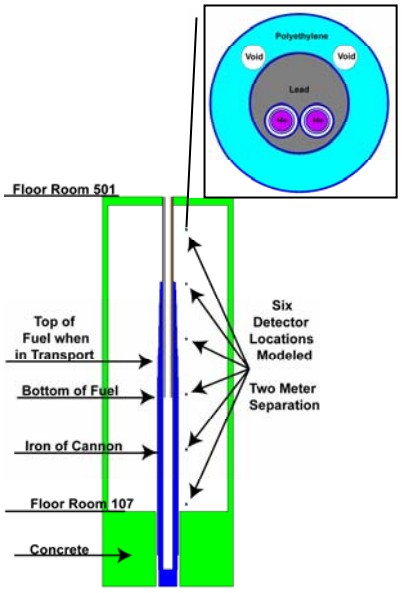
Unattended Monitoring



- Chernobyl conditioning facility will package and store spent fuel from decommissioned RBMK reactors
- Safeguards challenges include:
  - High gamma field from spent fuel
  - Continuity-of-Knowledge over spent fuel assemblies during rail transport
- Safeguards approach includes:
  - Gamma and neutron detectors with detector-triggered cameras
  - Tamper-resistant sensors and cameras on rail cars, capable of remote data transmission
- Effective unattended monitoring can reduce inspector workload and minimize health and safety risks

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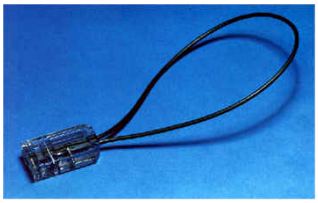
Containment/Surveillance (C/S)

DCM-14 Digital Camera Module

Cobra Fiber Optic Loop Seal



- Cameras and radiation detectors can monitor storage and process areas to ensure that there is no removal of nuclear materials
- Seals and tags can provide continuity-of-knowledge over feed, product, and waste containers as well as deter tampering with sensors and electronics
- Effective C/S can reduce the need for on-site inspector presence

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Advancing the State-of-the-Art

Challenges

- Large throughput facilities
- Undeclared production and clandestine activities
- Data integration
- Advanced fuel cycle facilities (e.g. GNEP)

New Approaches

- Systems analysis
- Modeling and simulation
- “Safeguards by design”
- Advanced detector materials and instrumentation
- Strengthened inspections (i.e. under IAEA Additional Protocol)
- International cooperation

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Advanced Measurements

Uranium Detection and Verification

- Measure U neutron emissions and flow rate of uranyl nitrate
- Neutron count and flow rate used to verify throughput of uranium conversion facility
- Advance the “starting point” of safeguards
- Follow-on applications could be useful for monitoring UF_6 in feed, product, and tails piping at gas centrifuge enrichment plants

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Next Generation Surveillance

- The IAEA’s Next Generation Surveillance System (NGSS) project will replace the DCM-14, which is reaching the end of its life cycle
- Major new features include:
  - Better image resolution, color, advanced industry standard image compression and file formats
  - Improved reliability to cover longer periods between inspections
  - Higher tolerance to radiation environments
  - Improved remote monitoring and remote state of health reporting capability
  - Compatible with other SG equipment systems and triggering sources
- Phase 1 Conceptual Design was completed in April 2006; Goal is to have a fully functional qualified system in 2009

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Advanced Sealing Systems

- Priorities include remotely monitored seals and in-situ verification of existing metal seal cup
- Current USSP projects include:
  - Change Detection Software Applied to Metal Seal Signatures
  - Feasibility study of ultrasonics for in-situ verification of metal seals
  - COBRA Fiber Optic Seal System Upgrade
  - Vulnerability assessments of New Adhesive Seal and Tamper Indicating Foil
- Other potential projects include:
  - Eddy Current Based Containment Verification System
  - Vulnerability assessment of Ultrasonic Sealing Bolt
  - Workshop on Future Sealing and Containment Verification Techniques
  - Laser Surface Authentication (LSA) for in-situ verification of metal cup seals

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Safeguards Approaches for Advanced Fuel Cycle Facilities

- Advanced fuel cycle facilities, in particular large-scale fuel processing and fabrication facilities, require verification of process material and hold-up during routine operations
- Modeling and systems analysis can identify inventory and flow key measurement points of interest for safeguards purposes
- Advanced measurement and monitoring systems must be integrated early in the facility design and construction process to minimize the impact on the operator
- Hold-up NDA measurements must have higher accuracy in order to reduce the uncertainty inherent in continuous monitoring
- Advanced process monitoring must be combined with automated data collection and analysis in order for the IAEA to meet timely detection requirements

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Summary

- Safeguards approaches must evolve to meet new challenges, including advanced fuel cycle facilities
- Advancing the safeguards “state-of-the-art” requires early modeling and analysis of facility process flow sheets as well as integration of advanced measurement instrumentation and monitoring systems into facility design and construction
- Technology development needs include uranium verification and detection, portable DA/NDA, unattended and remote monitoring, containment and surveillance, data integration and analysis
- Institutional and legal measures such as the IAEA Additional Protocol must parallel technological and methodological improvements

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