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# Non-Proliferation, the IAEA Safeguards System, and the Importance of Nuclear Material Measurements

## Fundamentals of Non-Destructive Assay for International Safeguards

Los Alamos National Laboratory  
September 25, 2017

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LA-UR-17-



**SAFEGUARD** NUCLEAR MATERIALS TO  
PREVENT THEIR DIVERSION OR THEFT



**CONTROL** THE SPREAD OF WMD-RELATED  
MATERIAL, EQUIPMENT AND TECHNOLOGY



NEGOTIATE, MONITOR AND **VERIFY**  
COMPLIANCE WITH INTERNATIONAL  
NONPROLIFERATION AND ARMS CONTROL  
TREATIES AND AGREEMENTS



**DEVELOP** PROGRAMS AND STRATEGIES TO  
ADDRESS EMERGING NONPROLIFERATION  
AND ARMS CONTROL THREATS AND  
CHALLENGES



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## Terminal Learning Objective

- Explain the contribution of nuclear material measurements to the system of international verification of State declarations and the non-proliferation of nuclear weapons



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# Enabling Learning Objectives

- Summarize the primary objective of nuclear non-proliferation
- List the main treaties and agreements that make up the legal framework for international safeguards
- Describe the international safeguards system and the importance of independent verification of nuclear material declarations
- Given the essential need for independent verification, explain the importance of nuclear material measurements



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# Historical Context



1945

First test of a  
nuclear  
weapon



1946

Baruch  
Plan/  
Soviet  
Response



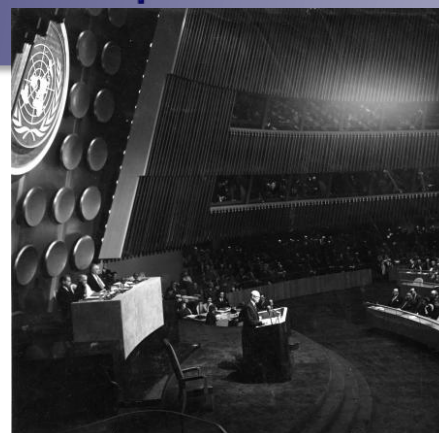
First Soviet nuclear test, Joe 1, Semipalatinsk Test Site, 1949.

1949

Soviet  
Union  
tests  
nuclear  
weapon

1953

Atoms for  
Peace  
Speech



1957

IAEA  
Created

1970

NPT  
enters  
into  
Force



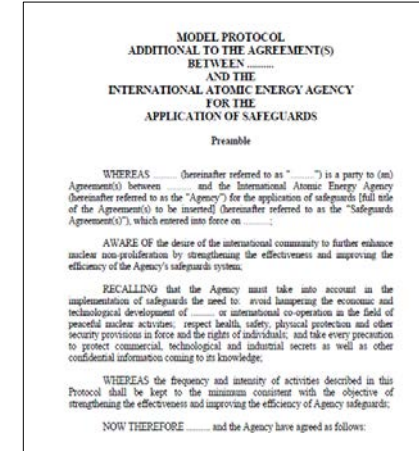
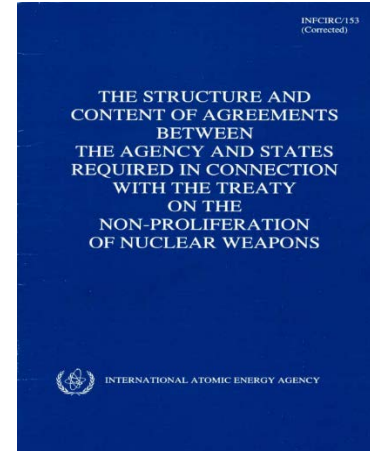
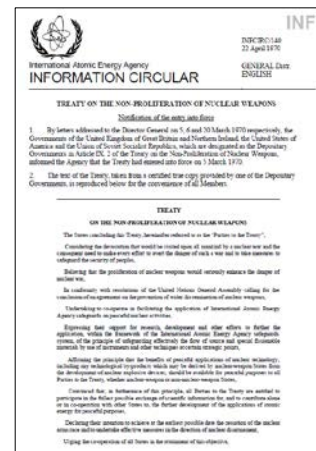
# Legal Framework for Safeguards

- **Non-proliferation Treaty (NPT):**

Each Non-nuclear-weapon State Party to the Treaty **undertakes to accept safeguards [...]**, for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty [...]

- **Comprehensive Safeguards Agreement (CSA):**

[...] Agency's right and obligation to ensure that safeguards will be applied **on all source or special fissionable material in all peaceful nuclear activities** within the territory of the State, under its jurisdiction or carried out under its control anywhere, for the exclusive purpose of **verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.**





# State's Undertaking and the Agency's Right and Obligation



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**State** – Accept safeguards **on all source or special fissionable material** in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere ...

*INFCIRC/153 (Corr.), para 1*

**IAEA** – Ensure that safeguards are applied **on all source or special fissionable material** in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere ...

*INFCIRC/153 (Corr.), para 2*



# CSA: Rights and Obligations

## State

- Cooperate with the IAEA
- Establish a State system for accounting and control of nuclear material – an **SSAC**
- Provide **information** to the IAEA
- Provide **access** to IAEA inspectors

## IAEA

- Cooperate with the State
- Maintain confidentiality of information
- Conduct independent measurements and observations
- Take account of technological developments



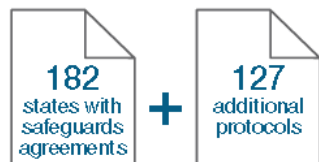
# Department of Safeguards

## IAEA SAFEGUARDS 2015

### ENSURING THE PEACEFUL USE OF ALL NUCLEAR MATERIAL

#### I. OUR MANDATE

##### OUR LEGAL FRAMEWORK



##### OUR COVERAGE



200,110 significant quantities of nuclear material



1,286 nuclear facilities and locations outside facilities

#### II. OUR VERIFICATION PROCESS

##### 1. COLLECT AND EVALUATE

785,085 nuclear material reports

40,408 open source items

4. DRAW CONCLUSIONS

181 conclusions  
↳ 67 broader conclusions

2. DEVELOP STATE-LEVEL APPROACHES

updated 6 state-level safeguards approaches

##### 3. PLAN, CONDUCT AND EVALUATE

2,805 in-field verifications

967 nuclear samples

13,248 days in-field

23,300 seals

1,416 cameras

136 facilities with remote monitoring

#### III. OUR RESOURCES

##### OUR BUDGET



€132.5 million  
+ €43.3 million extra budgetary

##### OUR WORKFORCE



883 staff and contractors from 96 countries

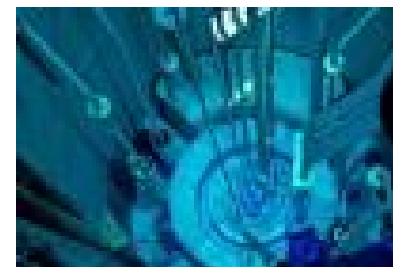
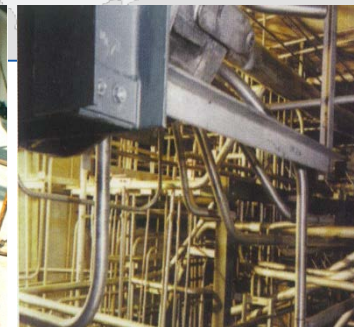


Primary Role:  
administer and  
implement IAEA  
Safeguards

Also contributes to  
nuclear arms control  
and disarmament



# IAEA In-Field Verification Activities



Design  
Information  
Verification

Inspections



Complementary Access



# IAEA Headquarters Activities

Accounting area identification      Report identification

PHYSICAL INVENTORY LISTING (PL) FORM R.02/03

COUNTRY: MM      DATE: 03/02/00  
FACILITY: NNS      REPORT NO.: 44  
NATIONAL BALANCE AREA: NNAB      PAGE NO.: 1 OF 3 PAGES      SIGNATURE: \_\_\_\_\_

ENTRY NO.	CONV. INVENT.	NAME OR NUMBER OF BATCH	NUMBERS OF ITEMS IN BATCH	ACCOUNTING AREA IDENTIFICATION	HEIGHT OF ELEMENT	UNIT	WEIGHT OF PISSE ISOTOPES (UPPERCASE ONLY) (G)	ISOTOPE CODE	REPORT NO.	ENTRY NO.
1	A	ISL 960	1	SV 1P	E	171991	G	5234		
2	A	ISL 968	1	SV 1P	E	171680	G	5211		
3	A	ISL 984	1	SV 1P	E	172193	G	5226		
4	A	ISL 985	1	SV 1P	E	172876	G	5217		

OVERVIEW - ARTICLES 2 AND 3 OF THE ADDITIONAL PROTOCOL

Item	Material	Quantity	Unit	Weight	Isotope	Code	Report	Entry
1	Plutonium-239	1	kg	171991	G	5234		
2	Plutonium-239	1	kg	171680	G	5211		
3	Plutonium-239	1	kg	172193	G	5226		
4	Plutonium-239	1	kg	172876	G	5217		

Material batch information





## What is Nuclear Material?

### Nuclear Material (NM):

- Any source or any special fissionable material as defined in Article XX of the Statute.
- Source material shall **not** be interpreted as applying to **ore or ore residue**.



Uranium (U)



Plutonium (Pu)



Thorium (Th)

in any physical or chemical form and in any quantities (*except ore*)



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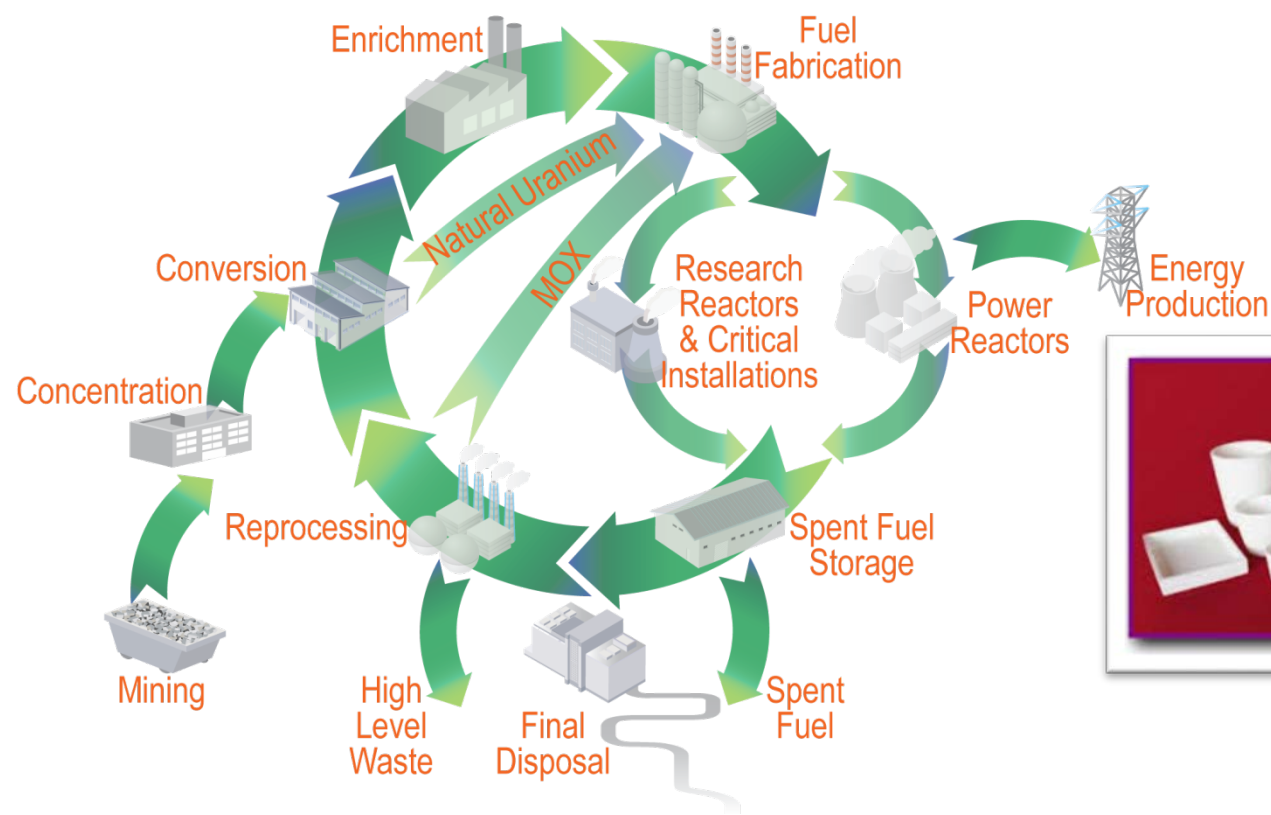
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# Where do you find Nuclear Material?

## In the Nuclear Fuel Cycle...



Moisture Meter

...And Non-Fuel Cycle applications



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# Why Measure Nuclear Material?

For Nuclear Material Accountancy:

- Facility operator
  - **Makes declaration for facility and provides to State Authority**
  - Needs to protect valuable assets, ensure safety, and assure higher-level authorities that nuclear materials are being used properly
- National and/or regional authority
  - **Reviews facility declaration and submits to IAEA**
  - Needs to exercise control over facilities, regulate transport, and provide information to regional or international authority
- International authority
  - **IAEA is responsible for verifying facility declaration**
  - Provides credible assurance to the international community that nuclear material and other specified items are not diverted from peaceful nuclear uses





# How do you measure nuclear material?

- Destructive Analysis: determining isotopic content and mass through analysis of a sample of material
- Non-Destructive Analysis: exploit radiation signatures of NM to characterize and measure



Mass spectrometer for  
Isotopics



Precision scales  
for chemical  
analyses



Confirmatory NDA systems  
for isotopics



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## Summary

- Nuclear non-proliferation seeks to promote the peaceful uses of nuclear technology while preventing the spread of nuclear weapons.
- The application of international safeguards is an obligation under the Non-Proliferation Treaty
- International safeguards rely on the independent verification of declared values of nuclear materials