Gas Centrifuge Technology: Proliferation Concerns and International Safeguards

Brian D. Boyer

Los Alamos National Laboratory

Trinity Section American Nuclear Society
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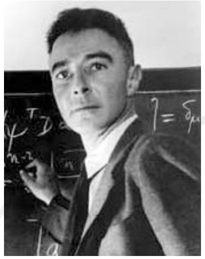
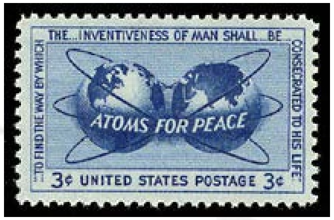


Enrichment / Proliferation / Safeguards



- Enrichment technology – The centrifuge story
- Proliferation of technology – Global Networks
- IAEA Safeguards – The NPT Bargain

Enrichment

Proliferation

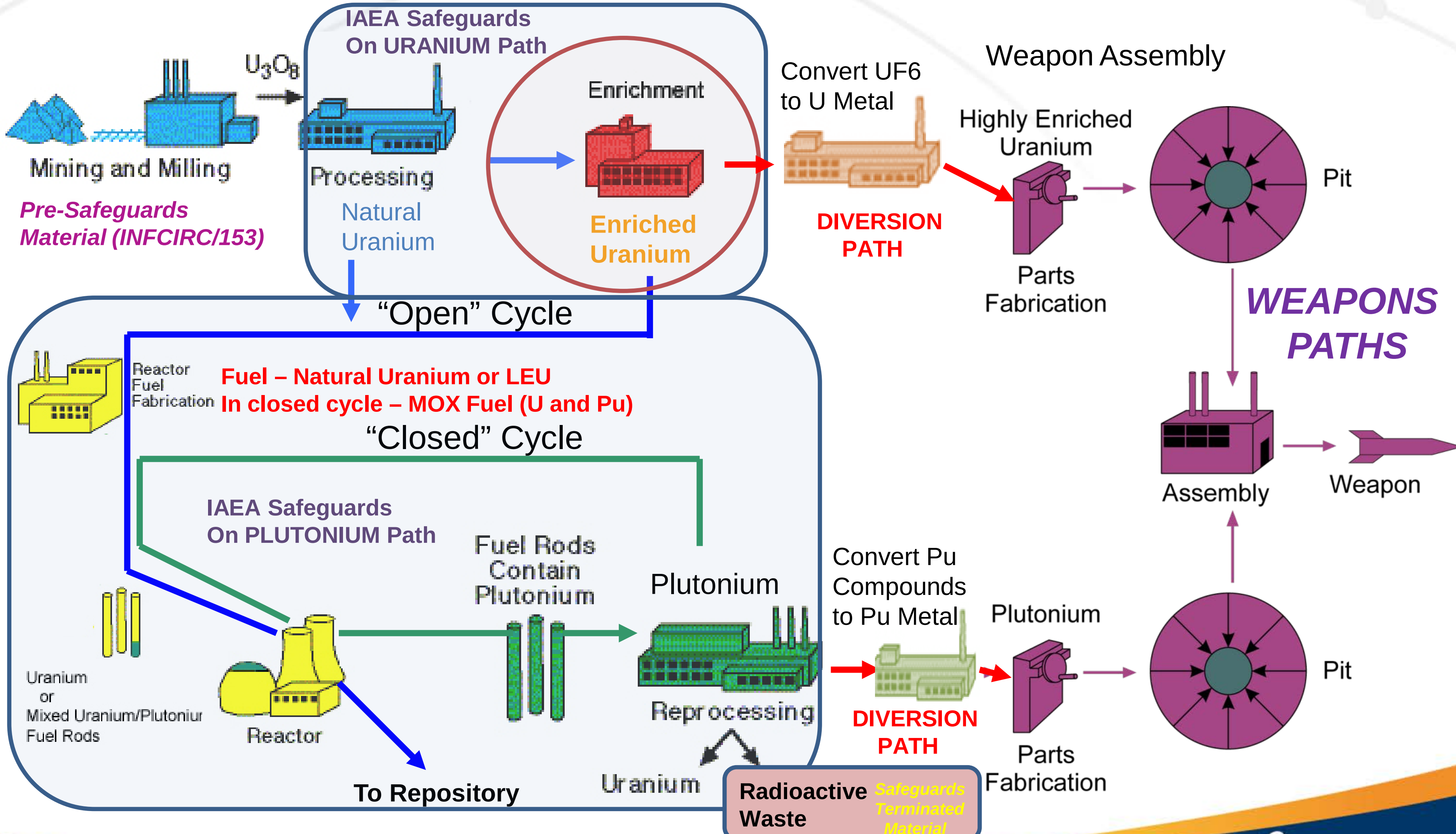
Safeguards

U.S. DOE Centrifuges – DOE /
Zippe Centrifuge – Deutsches Museum (Munich)
www.deutsches-museum.de/en/exhibitions/energy/energy-technology/nuclear-energy/

Pres. George W. Bush at ORNL briefed on seized Libyan nuclear equipment (ORNL)

B. Boyer and K. Akilimali - IAEA Safeguards Verifying Spent Fuel in Training in Sweden (Ski-1999)

The Nuclear Fuel Cycle and Proliferation Paths to WMDs



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Safeguards Concerns of U-235
IAEA Significant Quantities/Timeliness

DNLEU --- 75 kg U-235 in U (Wt% of U-235 <20%)

timeliness = 1 year **(NU = 0.711% U-235)**

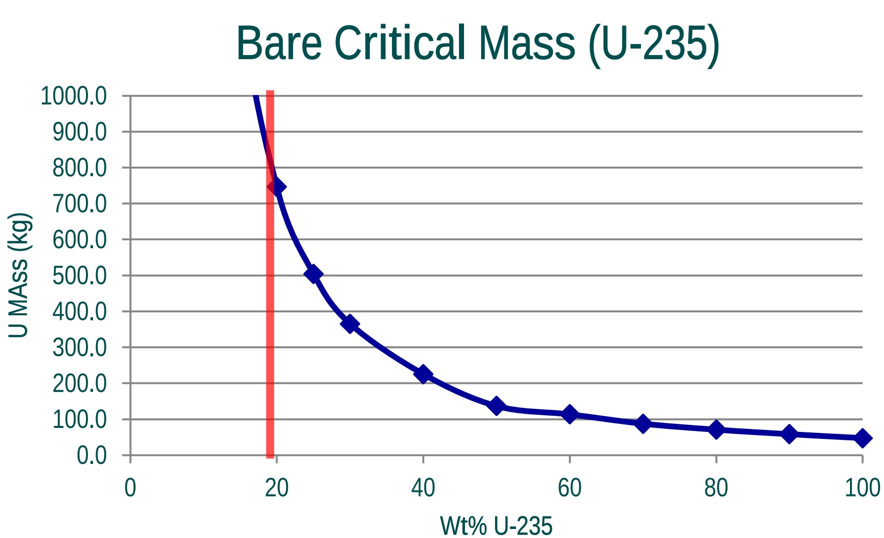
HEU --- 25 kg U-235 in U (Wt% of U-235 =>20%)

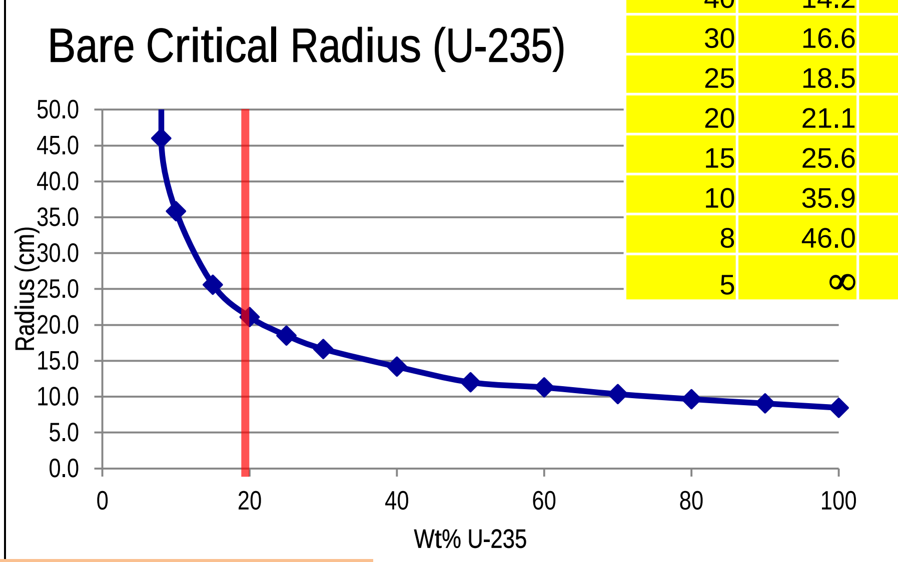
timeliness = 1 month (unirradiated) / 3 months (irradiated)

KEY POINT – NEED TO ENRICH URANIUM

BARE CRITICAL RADIUS & MASS

Weight % U235	R (cm)	Mass (kg)
100	8.5	47.5
90	9.1	58.4
80	9.7	70.9
70	10.4	87.5
60	11.3	113.5
50	12.0	136.7
40	14.2	225.5
30	16.6	365.6
25	18.5	504.7
20	21.1	746.3
15	25.6	1334.8
10	35.9	3663.2
8	46.0	7739.5
5	∞	∞





SOURCE: Forsberg, et al., *DEFINITION OF WEAPONS-USABLE URANIUM-233,* ORNL/TM-13517, MARCH 1998.

Uranium Enrichment: Review of History

- Centrifuge isotope separation suggested by Lindemann/Aston (1919)
- 1934 1st experiments at UVA in 1934 by Prof. Jesse Beams (CI)
- Uranium (U-238 99.3%, U-235 0.711%)…U.S. needs enriched U-235
  - Manhattan Project centrifuge efforts were unsuccessful
  - Manhattan Project enriched with varying success by
    - Thermal Diffusion (S-50) – Abandoned in 1945
    - EMIS – Electromagnetic Isotope Separation (Y-12)
    - Gaseous Diffusion (K-25)
  - Oak Ridge used 1/7 of the electricity of the United States

U. of Virginia

Jesse W. Beams

Courtesy H. Wood

EMIS Collectors at The National Museum of Nuclear Science & History – Albuquerque, NM
(Photo – B. Boyer 9/11/09)

The Clinch River curves around S-50 and the power plant for K-25, Oak Ridge.

SOURCE: The Manhattan Project an interactive history https://www.osti.gov/manhattan-project-history/Events/1942-1944_ur/navy_ltd.htm

Site of Massive Gaseous Diffusion Plant in FRANCE
GB I - Pierrelatte, FRANCE - from SNCF passenger train
(Photo – B. Boyer 2/1/08)

Uranium Enrichment: Post War Advances

Gernot Zippe over Oak Ridge

Courtesy H. Wood

- After the war gaseous diffusion process used in the West
- USSR developed centrifuges – how?
  - Used captured Third Reich scientists – G. Zippe (*Universität Wien*) Luftwaffe
- Europe successful with centrifuges in 1970's – URENCO
- Operating URENCO plants – world leader in enrichment
  - Capenhurst UK
  - Almelo NL
  - Gronau GFR
  - Eunice, NM USA

  - Technology shared by AREVA and URENCO (ETC) (at GBII France)
- Flirtations with laser isotope separation (LIS) enrichment

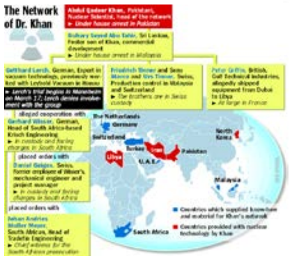
Centrifuges/21st Century Technology for Enrichment
Why Such Proliferation Concerns/Daily Headlines?

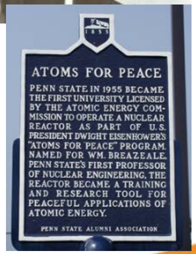
- "Rule of Thumb" on Enrichment capacity
  - ~5 MTSWU/yr capacity to go from NU to HEU (90%)
- Key Safeguards Issues
  - Diversion of Nuclear Material
  - Misuse of facility to produce enriched uranium
  - Undeclared capacity in undeclared plants

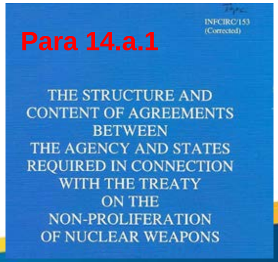
- Aspects of concern with Gas Centrifuge
  - Compare to Gaseous Diffusion Plant (GDP) – Energy use and size
    - 1/50th electrical consumption – less waste heat /smaller footprint
  - Compact size of centrifuges – 1-3m tall / 0.5m Dia. tubes
  - Small specific inventory / Short equilibrium time

Centrifuges – Technology Diffusion

- Technology was limited to NWS and NPT NNWS
  - Khan network starting in Pakistan changed this status quo
  - Iran moved to acquire technology and build own industry
  - Libya, DPRK,…?
- Nuclear Supplier Group – Trigger List / Dual Use Items
- Iran operates declared plants with capability to make
  - 3-5% enrichment for LEU PWR reactor fuel (Bushehr)
  - 19.75% enrichment (almost HEU = 20%) for TRR
- Naval reactor – potential loophole in NPT
  - INFCIRC/153 - Description of "non-proscribed military activity"
  - Military desire of HEU for submarine fuel






Para 14.a.1

INFCIRC/153 (Corrected)

THE STRUCTURE AND CONTENT OF AGREEMENTS BETWEEN THE AGENCY AND STATES REQUIRED IN CONNECTION WITH THE TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS

Details of How Centrifuges Work

Enriching Power = Separative Work Unit (SWU) = ΔU ~ ZV²

ΔU(max) = SWU of a machine

1. **ΔU~** proportional to **Length (Z)**
2. **ΔU ~** proportional to **V²**
3. **ΔU** is independent of **width (a)**

Speed

$$V_{max} = \sqrt{\frac{T}{\rho}}$$

$$\text{frequency} = \frac{|velocity|}{2\Pi|radius|}$$

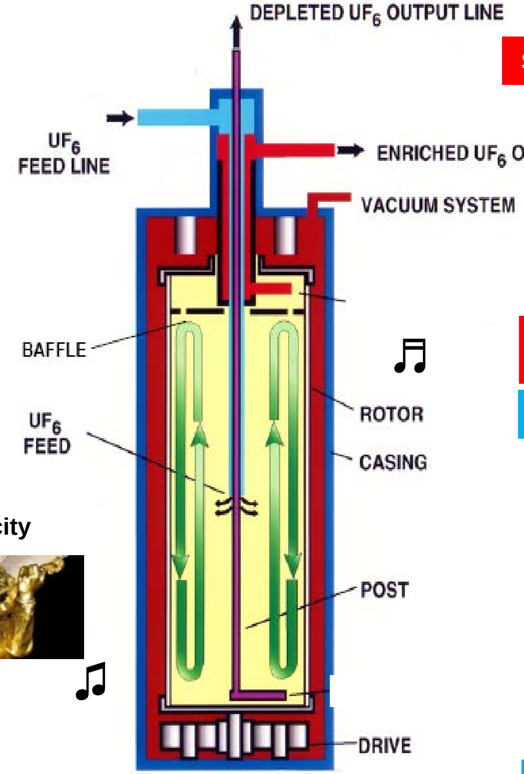
Relationship of Frequency and Velocity

V(max) = Maximum velocity of a machine

1. **T** = Tensile Strength (kN/m²)
2. ***ρ*** = Density (kg/m³)
3. Engineering need = strong but light materials
4. Al to Maraging Steel to Carbon Fiber

Fast – Tall – Strong - Light

SOURCE:
SAFEGUARDS TRAINING COURSE
NUCLEAR MATERIAL SAFEGUARDS FOR URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007) ORNL



Source: ORNL - SAFEGUARDS TRAINING COURSE NUCLEAR MATERIAL SAFEGUARDS FOR URANIUM ENRICHMENT PLANTS

Short Subcritical Centrifuges - RUSSIA

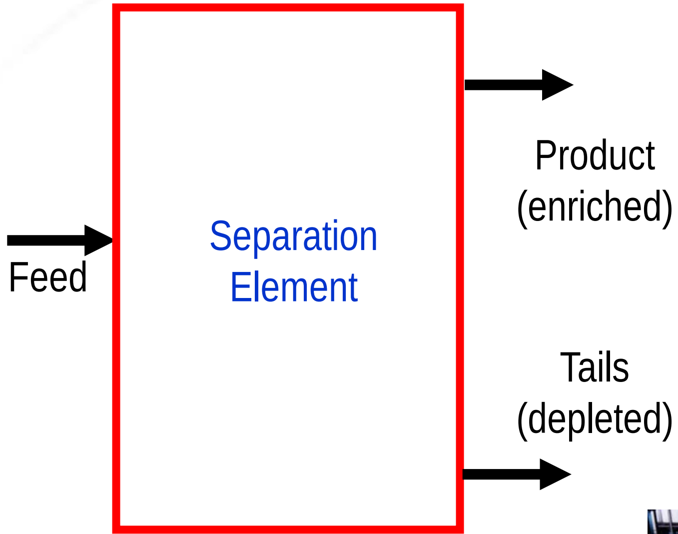
Source: Zippe G., Development and status of gas centrifuge technology, *Proc. 7th Workshop on Separation Phenomena in Liquids and Gases*, July 24-28, 2000, Moscow, Russia, pp.35-53.

Tall Ultra-Centrifuges - URENCO

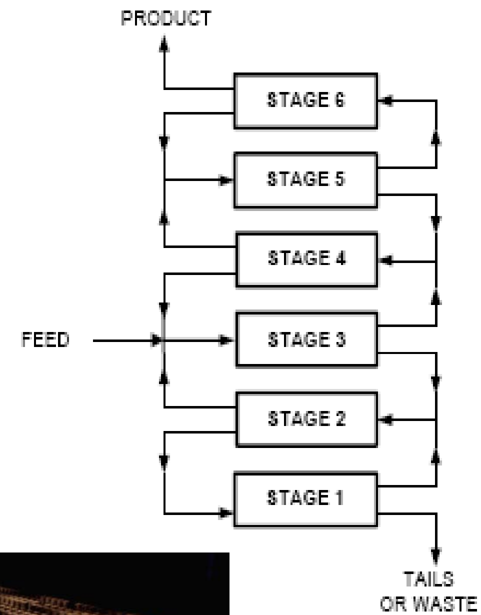
Source: FCIX 2013 Presentation: New Construction at LES/URENCO USA , Jay Laughlin Chief Nuclear Officer LES/URENCO USA June 12, 2013

Centrifuges and Cascades:
Enrichment Plant Theory

Single Centrifuge



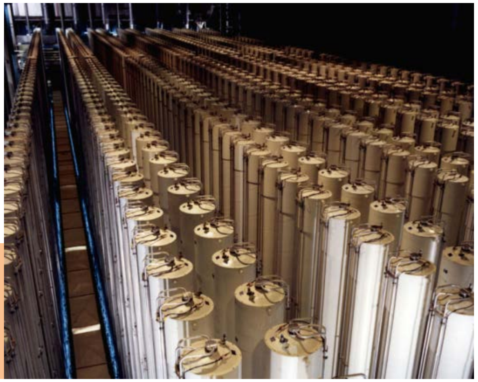
Centrifuges in Cascade



MULTIPLE STAGES ARE CONNECTED IN SERIES TO ACHIEVE USEFUL ENRICHMENTS

SOURCE:
SAFEGUARDS TRAINING COURSE
NUCLEAR MATERIAL SAFEGUARDS FOR URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007)
ORNL

Centrifuges
in Parallel / in Series



SOURCE: DOE

What is a UF6 Cylinder

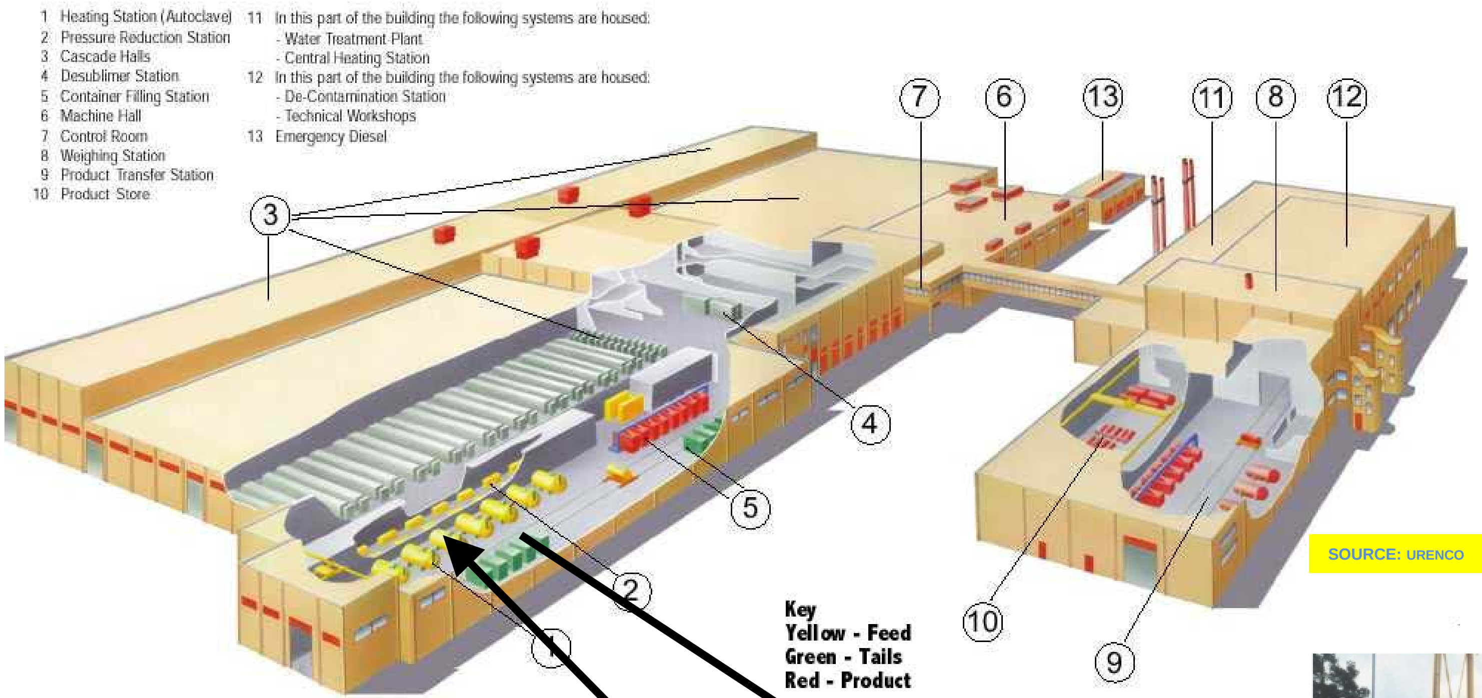
Where Inspectors Find/Verify U and U-235 Material

30B Product (2.5 ton)- Product

48Y (14 ton) – Feed and Tails

5a (25 kg) – HEU – Criticality Safe

Gas Centrifuge Enrichment Plant (GCEP)
Process and Storage Areas



SOURCE: URENCO

SOURCE: http://www.mein-duales-studium.de/fuer-schueler/partnerunternehmen/urenco-deutschland

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NNSA National Nuclear Security Administration

Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

IAEA Detection Goals - Perspective
Safeguards Focus on Iran’s Paths?

1. *Timely detection* of the **misuse of the facility to produce HEU** (or any UF6 at higher-than-declared enrichment levels)
2. *Timely detection* of **diversion of declared UF6**
3. *Timely detection* of the **misuse of the facility to produce undeclared LEU** (at declared enrichment levels) from undeclared feed
   - Obtain undeclared material (NU)
   - Enrich to LEU to be feed for clandestine HEU plant

Bushehr-1 (PWR/VVER-1000 Hybrid)
Fuel = 3.5% U-235 Enriched

- **Iran's VVER-1000 Reactor**
  - Maximum enriched 3.62% Russian fuel
- **Set up declared GCEPs capacity for**
  - 3-5% enriched Fuel
- **SWUs for production of HEU ~(90%) from LEU?**

Iran's Bushehr nuclear power plant. Photograph: Abedin Taherkenareh/EPA

SWU Calculator "Back of the Envelope EXCEL Model"

SOURCE:
SAFEGUARDS TRAINING COURSE
NUCLEAR MATERIAL
SAFEGUARDS FOR
URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007) ORNL

NU to LEU			LEU to HEU(90)			NU to HEU(90)		
XF	0.71%		XF	3.50%		XF	0.71%	
XP	3.50%		XP	90.00%		XP	90.00%	
XW	0.42%		XW	0.42%		XW	0.42%	
F=	60.85	**kgU235**	F=	28.30	**kgU235**	F=	60.85	**kgU235**
P=	28.30	**kgU235**	P=	25.02	**kgU235**	P=	25.02	**kgU235**
W=	32.55	**kgU235**	W=	3.28	**kgU235**	W=	35.83	**kgU235**
SQ HEU	1.13	**SQ HEU**	SQ HEU	1.00	**SQ HEU**	SQ HEU	1.00	**SQ HEU**
ΔU	**2.85**	**MTSWU**	**ΔU**	**1.79**	**MTSWU**	**ΔU**	**4.64**	**MTSWU**
	61.42%	**TOTAL SWUs**		**38.58%**	**TOTAL SWUs**		**100%**	**TOTAL SWUs**

KEY CALCULATION POINT:
61% of SWUs Done in LEU Stage

Source - B. Boyer Calculations (9/2014)

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Teheran Research Reactor (TRR) Fuel = 19.75% U-235 Enriched

- **Iran declares need for fuel for TRR**
  - 19.75% enriched Fuel – produce medical isotopes
- **Sets up declared GCEPs capacity for**
  - 19.75% enriched Fuel
- **SWUs for production of HEU? ~(90%)**

The Tehran Research Reactor.

http://iranprimer.usip.org/blog/2014/mar/06/realistic-options-final-nuclear-deal

SWU Calculator "Back of the Envelope EXCEL Model"

SOURCE:
SAFEGUARDS TRAINING COURSE
NUCLEAR MATERIAL
SAFEGUARDS FOR
URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007) ORNL

NU to LEU (19.75)			LEU(19.75) to HEU(90)			NU to HEU(90)		
XF	0.01		XF	0.20		XF	0.01	
XP	0.20		XP	0.90		XP	0.90	
XW	0.00		XW	0.00		XW	0.00	
F=	60.85	**kgU235**	F=	25.44	**kgU235**	F=	60.85	**kgU235**
P=	25.44	**kgU235**	P=	25.02	**kgU235**	P=	25.02	**kgU235**
W=	35.40	**kgU235**	W=	0.42	**kgU235**	W=	35.83	**kgU235**
SQ HEU	1.02	**SQ HEU**	SQ HEU	1.00	**SQ HEU**	SQ HEU	1.00	**SQ HEU**
ΔU	**4.15**	**MTSWU**	**ΔU**	**0.49**	**MTSWU**	**ΔU**	**4.64**	**MTSWU**
	0.89	**TOTAL SWUs**		**0.11**	**TOTAL SWUs**		**1.00**	**TOTAL SWUs**

KEY CALCULATION POINT:
89% of SWUs
Done in TRR Fuel
(2-Steps)
LEU reactor fuel
and 19.75%

Source - B. Boyer Calculations (9/2014)

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Non-application of Safeguards …
In Non-Peaceful Activities

Model Safeguards Agreement (1972) - INFCIRC/153(Corr.) Para. 14

The State shall inform the Agency of the activity, making it clear:

i. That the use of the *nuclear material* in a **non-proscribed military activity** will not be in conflict with an undertaking the State may have given and in respect of which Agency safeguards apply, that the *nuclear material* will be used only in a peaceful nuclear activity; and

ii. That during the period of non-application of safeguards the *nuclear material* will not be used for the production of nuclear weapons or other nuclear explosive devices;

Information Source: ***Nuclear submarine program surfaces in Iran***
*Posted on July 23, 2012 by Power & Policy By **Olli J. Heinonen** (Harvard) Former IAEA Deputy DG-SG*

http://www.css11.navy.mil/Subs/Asheville.htm
Toured in August 2011 at San Diego by LANL's R. Wallace, C. Murphy and B. Boyer

(AP Photo/Iranian Defense Ministry, Vahid Reza Alaei, File)

Photo – B. Boyer July 2013)

Iran’s Navy
Fuel = 5-90%? U-235 Enriched

- **Suppose Iran declares need for fuel for naval reactors**
  - Can set up need for 50-60% (HEU) Fuel
- **Navy enrichment/fuels program**
  - Non-application of safeguards – NPT
  - Plants unsafeguarded by IAEA?
  - Need about 5-6 SQs of material (50%-90% perhaps?)

KAPL D1G Prototype (John Carl D'Annibale / Times Union archive)

- **SWUs to get HEU 90%? ~(97% of SWUs) !!!**

SWU Calculator “Back of the Envelope EXCEL Model”

NU to HEU (54)			HEU(54) to HEU(90)			NU to HEU(90)		
XF	0.71%		XF	54.00%		XF	0.71%	
XP	54.00%		XP	90.00%		XP	90.00%	
XW	0.42%		XW	0.42%		XW	0.42%	
F=	60.84606	**kgU235**	F=	25.09845	**kgU235**	F=	60.84606	**kgU235**
P=	25.09845	**kgU235**	P=	25.02	**kgU235**	P=	25.02	**kgU235**
W=	35.74761	**kgU235**	W=	0.07845	**kgU235**	W=	35.82606	**kgU235**
SQ HEU	1.003938	**SQ HEU**	SQ HEU	1.0008	**SQ HEU**	SQ HEU	1.0008	**SQ HEU**
ΔU	**4.486542**	**MTSWU**	**ΔU**	**0.149555**	**MTSWU**	**ΔU**	**4.636098**	**MTSWU**
	96.77%	**TOTAL SWUs**		**3.23%**	**TOTAL SWUs**		**100%**	**TOTAL SWUs**

KEY CALCULATION POINT:
97% of SWUs
Done for 54% enriched reactor
3 Enrichment Stages

SOURCE:
SAFEGUARDS TRAINING COURSE
NUCLEAR MATERIAL
SAFEGUARDS FOR
URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007) ORNL

Source - B. Boyer Calculations (9/2014)

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The Iran Snapshot – Latest Status of UF6

Source: IAEA
GOV/2014/28
(Derestricted BOG 4 June 2014)
Date: 23 May 2014
http://www.iaea.org/newscenter/focus/iran/iaea-and-iran-iaea-reports

ISFAHAN

NATANZ FEP

	Conversion NU UF6	UF6 Feed to GCEPs	UF6 GCEPs Product	UF6 GCEPs Tails
kg UF6	550000	134843	11870	122973
kg U	371855	91167	8025	83142
Enrichment	0.711%	0.711%	3.49%	0.49%
kg U-235	2643.9	648.2	280.1	404.1
SQ DNLEU U-235	35.3	8.6	3.7	5.4
SQ U-235 (25kg)	105.8	25.9	11.5	16.2
Cylinders 48 in	44.0	10.8		9.8
Cylinders 30 in			5.3	

Isfahan EUPP and UCF plants

Natanz GCEP

Fordow GCEP

Questions for IAEA BOG and UNSC

- Iran has enough LEU feed for producing SQ of HEU
- ~2/3 to 3/4 of the SWU for getting 90% HEU complete in LEU
- Will Iran divert LEU to a Plant "X"?
- Will Iran breakout at Natanz, etc… or at a possible secret Plant "X"?
- Can Iran make HEU? Options? Naval reactors?
- Less than optimal LEU production so far but on a learning curve

Source - B. Boyer Calculations of IAEA data (6/2014 and 9/2014)

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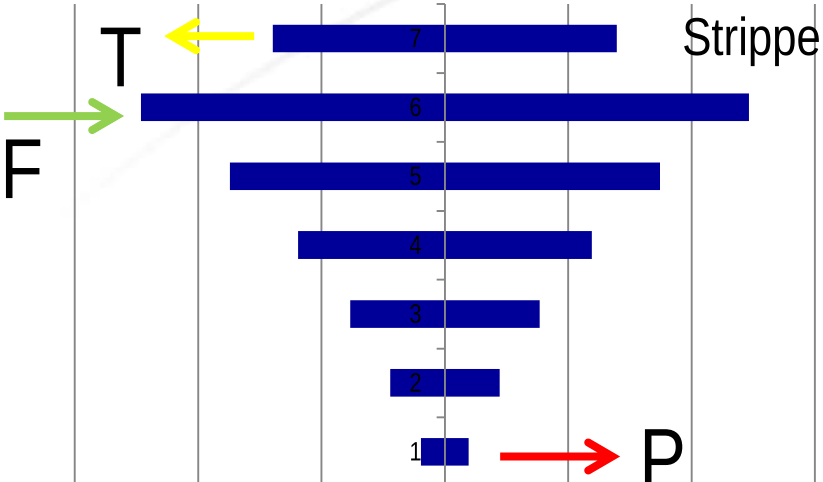
Ideal Cascade – Use of IAEA Board Reports

Scale of Operations



IDEAL CASCADE MODEL

Stripper Stage (1)

1 Centrifuge =	1 SWU/yr

Enricher Stages (5 +1 = 6)

Ideal Cascade
"Back of the Envelope
EXCEL Model"

Cascade at Natanz

SOURCE:
SAFEGUARDS TRAINING COURSE
NUCLEAR MATERIAL
SAFEGUARDS FOR
URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007) ORNL

- Natanz Model estimated from BOG Reports
- Assume – ~50 cascades of ~200 centrifuges

–

F=	26382	kgU/yr	188	kgU235/yr	0.711%	**NU**
P=	2552	kgU/yr	88.2	kgU235/yr	3.5%	**LEU**
W=	23829	kgU/yr	101	kgU235/yr	0.42%	**DU**

IDEAL CASCADE MODEL
~50 x ~200 =

Source - B. Boyer Calculations (9/2014)

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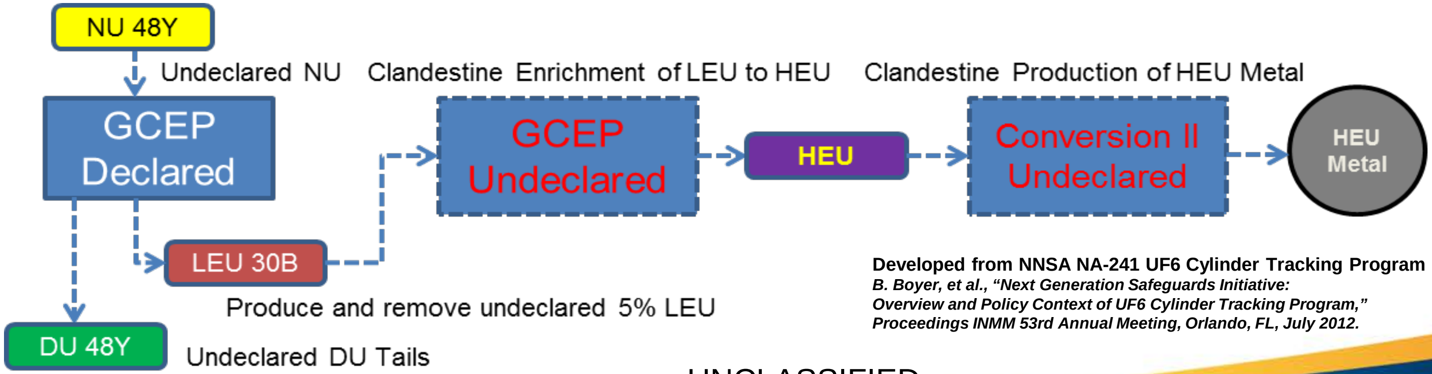
NNSA National Nuclear Security Administration

Diversion/Breakout/Clandestine Pathways

Acquisition Pathways?

1) Misuse at Natanz of declared ~50 cascades x ~200 machines
   - Take LEU and enrich to HEU - up to 4 stages total
2) Divert LEU to Plant "X" – clandestine HEU enrichment plant
3) Divert of tails to Plant "Y" – clandestine HEU enrichment plant
4) Clandestine NUF6 at Plant "Z"
   - Clandestine conversion or acquisition of NUF6
   - Enrich – NU to HEU at Plant "Z"



Developed from NNSA NA-241 UF6 Cylinder Tracking Program
B. Boyer, et al., "Next Generation Safeguards Initiative: Overview and Policy Context of UF6 Cylinder Tracking Program," Proceedings INMM 53rd Annual Meeting, Orlando, FL, July 2012.

Path 1 - Breakout or Misuse at Natanz

- **LEU from Natanz as feed ~7800 kgUF6 avail. = (3.5x30B)**
- **Stage 2 – F 3.5%, P 19.2%, T 0.733%**
  - 55 days – produce 40kgU235
- **Stage 3 – F 19.2%, P 61%, T 3.5%**
  - 11 days – produce 28.6kgU235
- **Stage 4 – F 61%, P 91%, T 19.2%**
  - 4 days – produce 25kgU235
- **1 SQ of U235 produced – ~10 weeks of production**
- **Less than 3 months to breakout *or* misuse Natanz**

Source - B. Boyer Calculations (9/2014)

Path 2 - Diversion of LEU to Possible Plant "X"

- Take LEU at Natanz as feed - ~7800 kgUF6 available ~(3.5x30B)
- Divert ONE 30B to possible Plant "X" – attempt to hide diversion
- Plant "X" ~3000 centrifuges ~ similar to Fordow plant – secret location
- Built as one *optimized cascade* to go from LEU to 91% HEU
  - 20 stages up / 2 stages down – P=91% U235, T=1.59% U235
  - 21 enrich / 2 strip stages
  - 140 days – produce 25 kgU235
  - Feed for 1 SQ? = 1916 kgUF6 at 3.5% enrichment (<1 X 30B)
- **~5 months** to use Plant "X" to process secretly LEU

OPTIMAL LEU to HEU CASCADE MODEL

Source - B. Boyer Calculations (9/2014)

Path 3 - Diversion of DU tails to Possible Plant "Y"

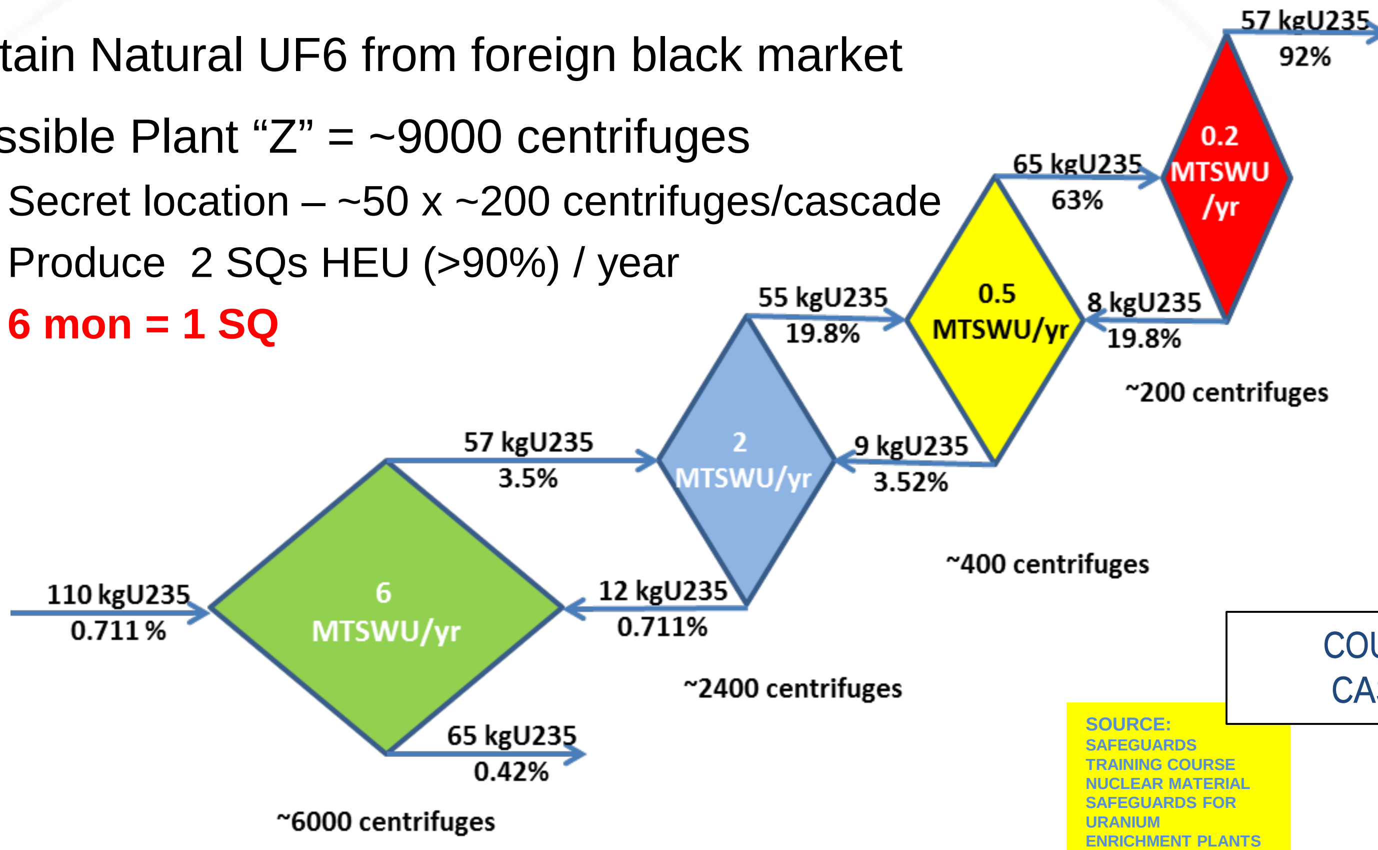
- Take DU at Natanz as feed - ~123 tonnes UF6 (0.49% U235) ~(10x48Y)
- Divert 48Y (**1/10**) to Plant "Y" – attempt to hide diversion – 12,500 kgUF6
- Plant "Y" ~3000 centrifuges ~ similar to Fordow plant scale – secret location
- Built as one *optimized cascade* to go from DU to 87% HEU
  - 26 stages up/3 stages down – P=87% U235, T=0.17% U235
  - 27 enrich / 3 strip
  - **~3 years** – produce 46 kgUF6, 31 kgU, 27 kgU235
- Clandestine plant designed to enrich NU to HEU
  - Can use ONE tails cylinder to produce SQ of HEU (87%)

OPTIMAL DU to HEU CASCADE MODEL

Source - B. Boyer Calculations (9/2014)

Path 4 - Clandestine Ops - Possible Plant "Z"

- Mine U ore / obtain foreign ore clandestinely and convert to UF6 in possible clandestine NU conversion plant
- Obtain Natural UF6 from foreign black market
- Possible Plant "Z" = ~9000 centrifuges
  - Secret location – ~50 x ~200 centrifuges/cascade
  - Produce 2 SQs HEU (>90%) / year
  - **6 mon = 1 SQ**



COUPLED 4 STAGE CASCADE MODEL

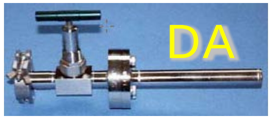
SOURCE:
SAFEGUARDS TRAINING COURSE NUCLEAR MATERIAL SAFEGUARDS FOR URANIUM ENRICHMENT PLANTS
ISPO-347/R8 (JUNE 2007) ORNL

Source - B. Boyer Calculations (9/2014)

IAEA - Detecting Diversion of Uranium

- **IAEA Inspection regime includes:**
  - Annual Physical Inventory Verification (UF6 on site, DIV, analysis of data)
  - Interim inspections for flow verification (scale of facility) (URENCO - monthly)
    - Iran how many times? Scale of operations? 1x, 4x, 12x per year???
  - IAEA verifies feed, product, and tails cylinders - Receipts and Shipments
    - OPERATOR holds feed before feeding to process
    - OPERATOR holds tails and product before shipment off-site
- **Verification of nuclear material (flows and inventories)**
  - Nondestructive Assay (NDA) / Destructive Assay (DA) [Statistical Sampling]
- **Environmental Swipe Samples – powerful tool to detect HEU**
  - For declared facilities and looking for undeclared activities and facilities

PATH	Type	Time (months)
1	Three Stage Misuse – LEU-to-HEU	2.5
2	Plant X – LEU-to-HEU	5
3	Plant Y – DU-to-HEU	36
4	Plant Z – NU-to-HEU	6



Verify Design Information via LFUA

- **Low Frequency Unannounced Access (LFUA) Inspections**

  - Access is on a random, unannounced basis
  - Access must be provided within 2 hours of request
  - Performed 4 -12 times per year (<1000MTSWU/yr)
    - During planned inspections
    - Totally unannounced

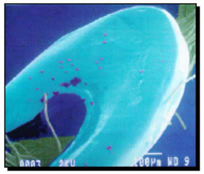
  - Protection of proprietary information by negotiated procedures

Environmental Swipe Samples

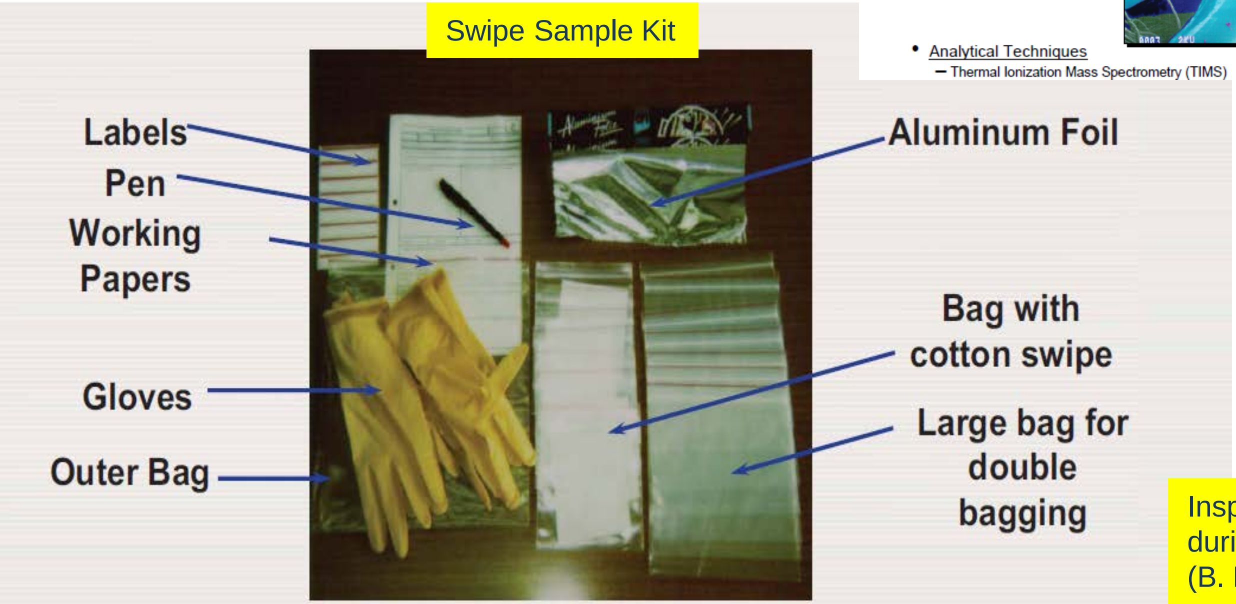
- **Environmental Sample Swipe Kit**
  - Powerful tool for undeclared activities
  - Detect HEU where not declared
  - Where to swipe?
  - Avoid Contamination / Site Legacy

Particle Analysis

- Detection and analysis of individual micron-size particles containing fissionable materials



- Analytical Techniques
  - Thermal Ionization Mass Spectrometry (TIMS)



Inspectors demo ES techniques during BNL APEX Training (B. Boyer)

Enrichment / Proliferation / Safeguards
Summary of Issues

- **Enrichment is a sensitive technology**
  - Technology diffusion – Zippe / Khan / (Future Lasers?)
  - Export controls – nuclear technology / dual use
  - Safeguarding the technology by the technology holders
- **Proliferation**
  - Iran – Open questions on nuclear dossier
  - Libya – Intercepted centrifuges – “Black Market”
  - DPRK – Revelation of GCEP – seen by Sig Hecker
- **GCEPS safeguards**
  - Timely detection of the misuse of the facility to produce HEU
  - Timely detection of the diversion of declared UF6
  - Timely detection of misuse of facility to produce undeclared LEU
  - Breakout vs. Clandestine Ops
  - Need for robust safeguards regime

Centrifuge Cases
Destined for Libya in USA

Inspector in Iran
2014

UNCLASSIFIED