Module 12

Throughput and Material Unaccounted For (MUF) or Inventory Difference (ID) Evaluations

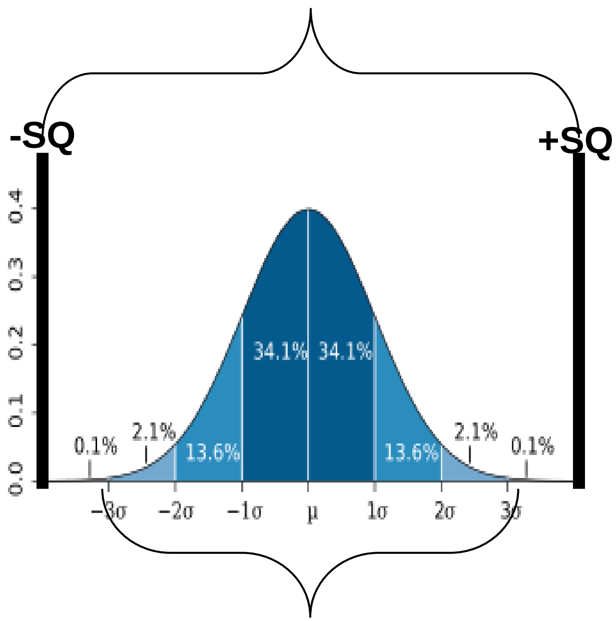
Learning Objectives

- Discuss the affect of throughput on the detection capability of the Materials Accounting elements.
- Discuss different regulatory requirements in the area of MUF/ID evaluation
- Identify regulations and approaches that address and manage detection capability at higher throughputs
- Discuss application to hypothetical facility bulk process

Process Capability Considers Process Variability Relative to Detection Goals to Determine if the Process is “Capable”

Very Capable

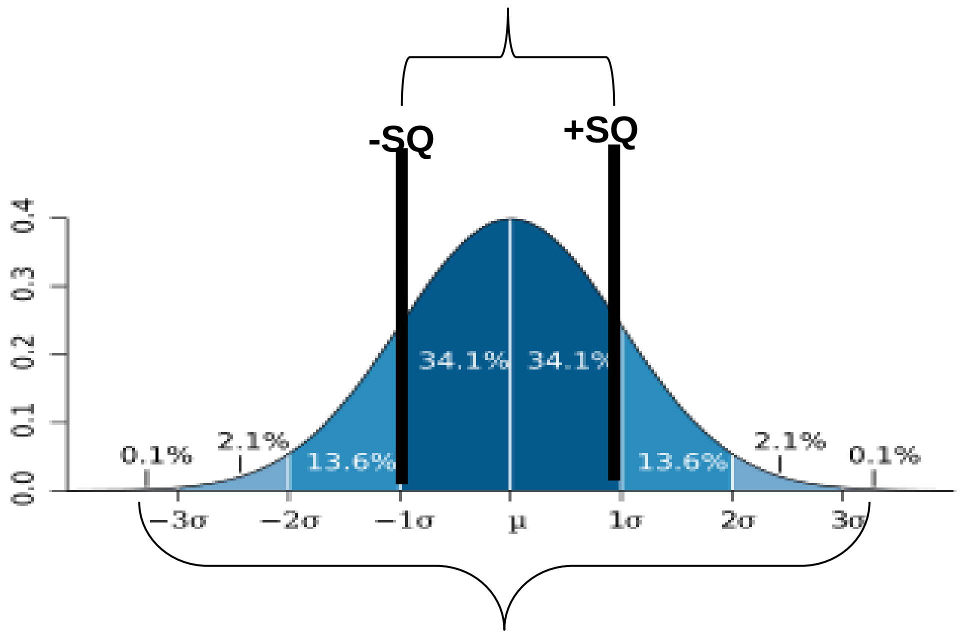
Safeguards Limits or what we would like to detect



Due to process uncertainty what we can detect.

Not Very Capable

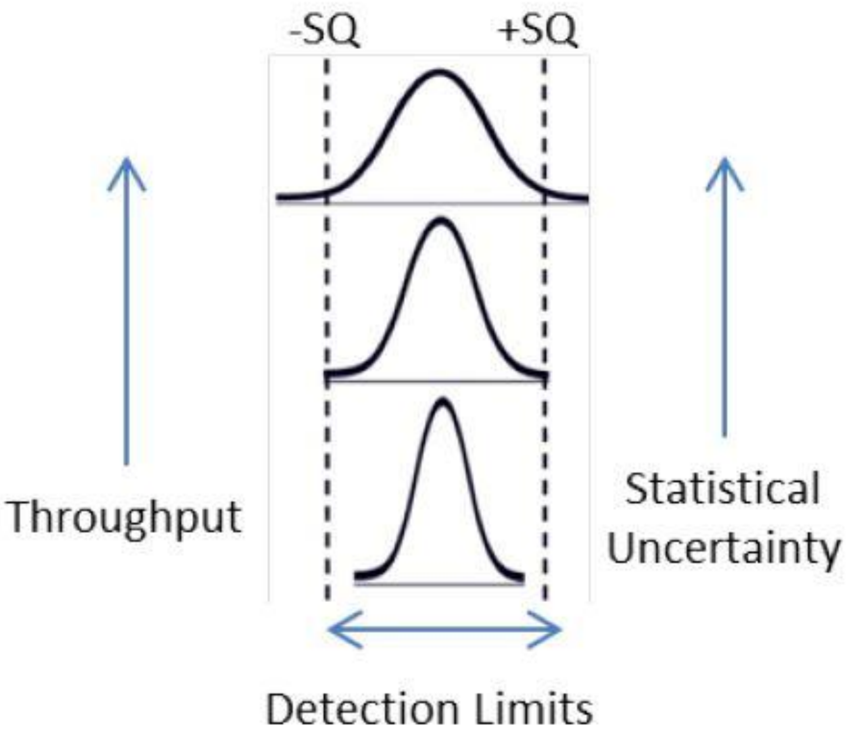
Safeguards Limits or what we would like to detect

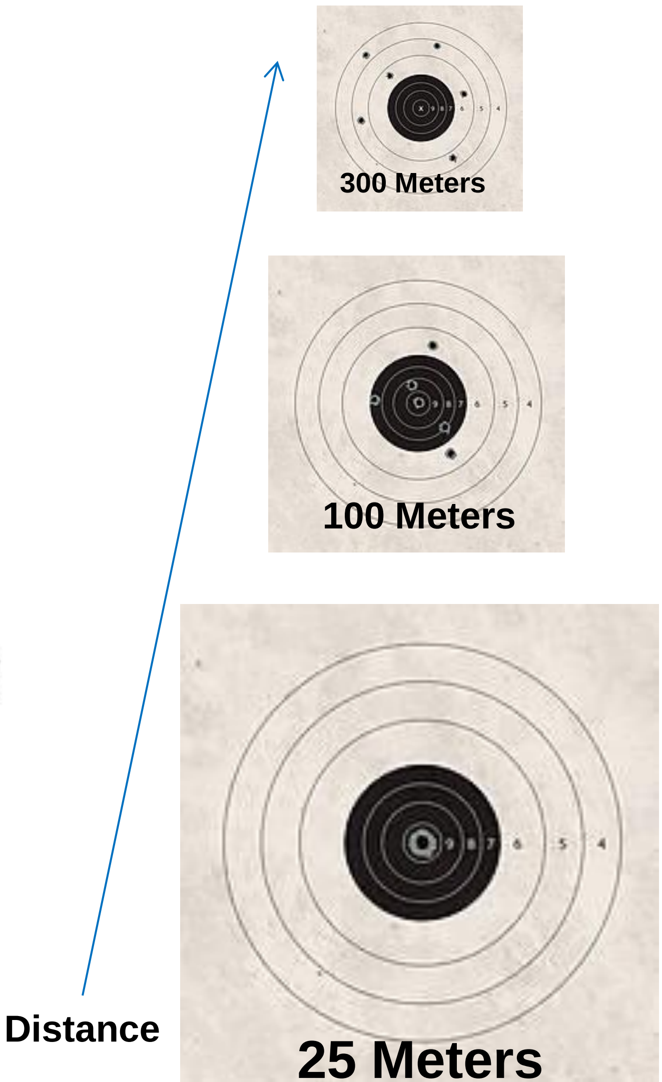


Due to process uncertainty what we can detect.

As throughput increases, the ability to detect decreases (i.e., less capable) due to statistical uncertainty.

Nuclear Process is like **Target Shooting**





Operating Facility Reference Throughputs

The next 3 slides are references for the design capacities of some of the currently operating facilities in the world. The types of facilities covered are:

- LEU Conversion and Fuel Fabrication
- Mix Oxide Fuel Fabrication
- Spent Fuel Reprocessing

World Mixed Oxide Fabrication Capacity (tonnes/year)

Country	Facility	Product	Capacity
Belgium	BN/Dessel	LWR FRs	40
	FBFC Int'l	LWR FAs	120-200*
France	CFCa	FBR FAs	10
	CFCa	PWR FRs	40
	MELOX	PWR FAs	100
India	Tarapur	BWR FAs	18
Japan	PFFF	ATR FAs	10
	PFPF	FBR FAs	5
Russian Federation	Paket	FBR FAs	0.3
	ERC	FBR FAs	1
UK	MDF	PWR FAs	8
** 120 tonnes/yr(BWR only); 200 tonnes/yr (PWR only)*			

Reference: IAEA. *Technical Reports Series No. 45 - Status and Advances in MOX Fuel Technology.* Report, Vienna: IAEA, 2003.

Major Current Commercial LWR Spent Fuel Reprocessing Capacity

Country	Facility	Capacity (tonnes HM/yr)
France	LaHague	1700
UK	Sellafield (THORP)	900
Russia	Mayak	400
Japan	Tokai	90
	Rokkasho	800

Reference: http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Fuel-Recycling/Processing-of-Used-Nuclear-Fuel/#.UhEOBtLYiBQ

World LWR Fuel Fabrication Capacity (tonnes/year)

Country	Company	Location	Pelletizing
Belgium	AREVA NP-FBFC	Dessel	700
Brazil	INB	Resende	160
China	CNNC	Yibin	400
France	AREVA NP-FBFC	Romans	1400
Germany	AREVA NP-ANF	Lingen	650
India	DAE Nuclear Fuel Complex	Hyderabad	48
Japan	NFI (PWR)	Kumatori	360
	NFI (BWR)	Tokai-Mura	250
	Mitsubishi Nuclear Fuel	Tokai-Mura	440
	GNF-J	Kurihama	750
Kazakhstan	Ulba	Ust Kamenogorsk	2000
Korea	KNFC	Daejeon	600
Russia	TVEL-MSZ*	Elektrostal	1200
	TVEL-NCCP	Novosibirsk	200
Spain	ENUSA	Juzbado	300
Sweden	Westinghouse AB	Västeras	600
UK	Westinghouse**	Springfields	600
USA	AREVA Inc	Richland	1200
	Global NF	Wilmington	1200
	Westinghouse	Columbia	1500
** Includes approx. 220 tHM for RBMK reactors*			
*** Includes approx. 200 tHM for AGR reactors*			

Reference: http://world-nuclear.org/info/Nuclear-Fuel-Cycle/Conversion-Enrichment-and-Fabrication/Fuel-Fabrication/#.UhEMtdLYiBQ

Regulatory Requirements for MUF (ID) Limits

Russia and US:

	US NRC	Russia	DOE
SEID Exceeding	0.1% active inventory		1% active inventory half a Cat. II quantity
ID Exceeding	3x SEID **AND** 0.2kg Pu; 0.2kg U233; or 0.3kg U235 in HEU	3x SEID 3kg Pu/U233 8kg U235 [1]2% Industrial [1]3% R&D	
	[1]total quantity of NM that was converted and underwent accounting measurements during the material balance period		

China:

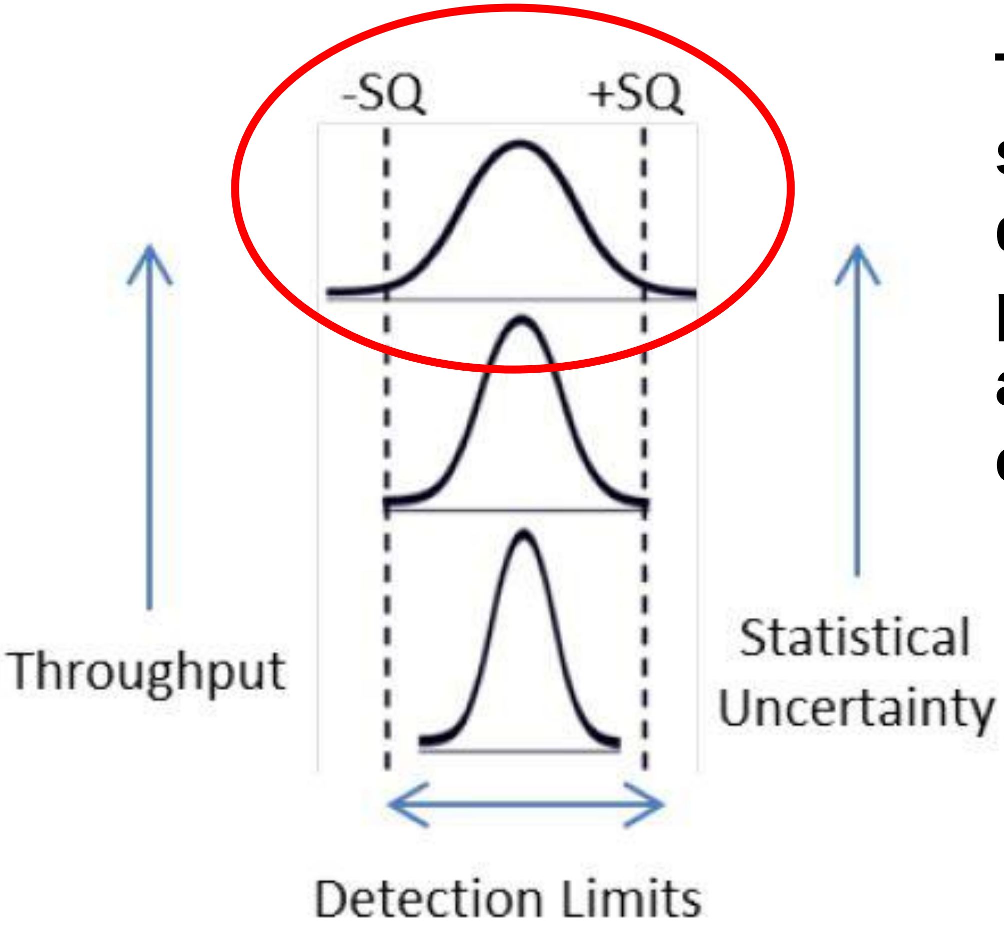
Type of Facility	σ (ID) (%)
U enrichment	0.2
U processing	0.3
Pu processing	0.5
U post-processing	0.8
Pu post-processing	1

Note: Regulatory References – Next viewgraph

Regulatory References:

- NRC: 10 CFR Part 74 - *Material Control and Accounting of Special Nuclear Material (10 CFR Part 74.53 Process Monitoring*) Washington DC: Nuclear Regulatory Commission
- U. S. Department of Energy Regulations
  - US DOE Order – DOE O 474.2 – Nuclear Material Control and Accountability – June 27, 2011
  - U.S. DOE Standard – DOE-STD-1194-2011 Chg 3 – Nuclear Materials Control and Accountability – Oct 2013
- Russian Regulations
  - *Federal Rules and Regulations Regarding the Use of Atomic Energy- NP-030-12 -, "Basic Nuclear Material Control and Accounting Rules" Adopted by the Federal Environmental, Industrial, and Nuclear Regulatory Authority Order No 255, Dated 17 April 2012.*
- Chinese Regulations
  - Nuclear Safety Guide HAD 501/01 – Nuclear Material Accountancy of LEU Conversion and Fuel Fabrication Facilities – Approved and Released by the Chinese National Nuclear Safety Administration September 1, 2008.
  - Nuclear Safety Guide HAF 501/01 – Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China - Released by National Nuclear Safety Administration, Ministry of Energy, and Commission of Science Technology and Industry for National Defense on September 25, 1990

What happens when limits set at a percent of throughput exceed a significant quantity?



The ability to detect significant losses can decrease to the point or practically non-existent at "normal" operating capacities.

Approaches and Regulations that Manage Uncertainty and Throughput

“**Process Monitoring** is an extended form of containment and surveillance especially supporting near-real-time materials accountancy that makes the best use of information mainly acquired by facility operators in order to detect unusual (anomalous, abnormal) conditions (activities, movements, situations) that might be indicative of diversions”.

IAEA. *STR-235 Current Status Of Process Monitoring for IAEA Safeguards.* Report, Vienna: IAEA, 1987.

“In some plants, where production can be stopped on a regular basis, the safeguards approach is based on a monthly **Short Inventory Verification (SIV)**. The operator then ensures that the majority of the material is moved into measurable locations, thus reducing in-process inventory to holdup and hidden inventory. In continuously operating plants, a safeguards approach based on frequent inventory verification of a running process has been adopted by Euratom.

ESARDA, Bulletin, No. 31, *Control of Nuclear Material Holdup in MOX Fuel Fabrication Plants in Europe,* ISPRA, Italy April 2002

Better Definition of Process Monitoring

"Process Monitoring is a methodology to ensure that special nuclear material (SNM) is in its authorized location and when effectively implemented, it is a useful tool to detect anomalous process conditions and indicate losses of SNM well before the scheduled physical inventory."

U.S. DOE Standard – DOE-STD-1194-2011 Change 3 – Nuclear Materials Control and Accountability, Paragraph 6.2.4.5– Oct 2013

NRC Process Monitoring Regulations

Unit Process Detection Capability **-** For each unit process, a licensee shall establish a production quality control program capable of monitoring the status of material in process. The program shall include:

Industrial Operations

(1) A statistical test that has at least a 95 percent power of detecting an **abrupt loss of five *formula kilograms* within three working days** of a loss of Category IA material from any accessible process location and within seven calendar days of a loss of Category IB material from any accessible process location;

(2) A quality control test whereby process differences greater than three times the estimated standard deviation of the process difference estimator **AND** 25 grams of Strategic Special Nuclear Material (SSNM) are investigated;

(3) A trend analysis for monitoring and evaluating sequences of material control test results from each unit process to determine if they indicate a pattern of losses or gains that are of safeguards significance.

NRC: 10 CFR Part 74 - Material Control and Accounting of Special Nuclear Material (10 CFR Part 74.53 Process Monitoring) Washington DC: Nuclear Regulatory Commission

DOE Process Monitoring Regulations

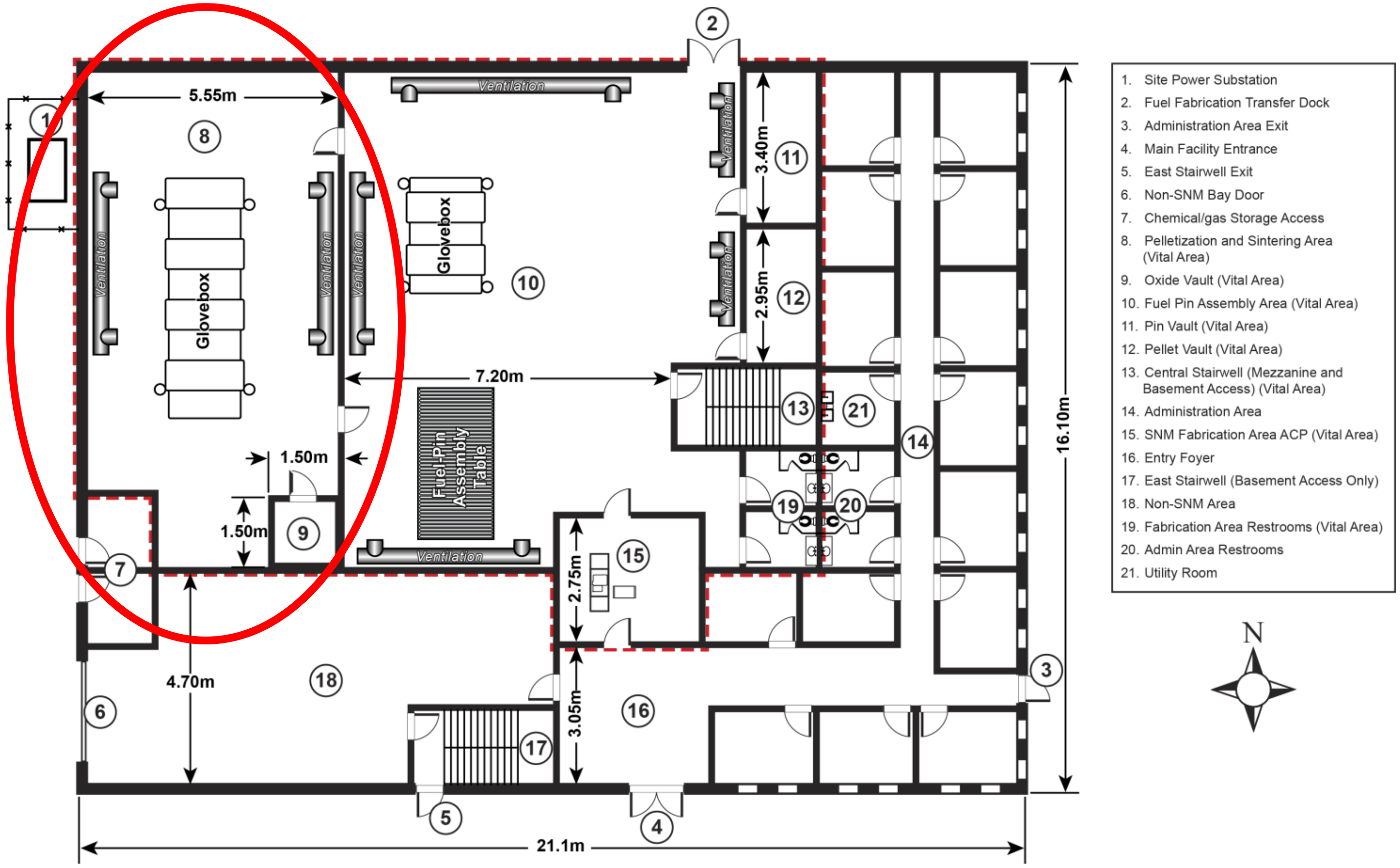
Process monitoring is a methodology to ensure that SNM is in its authorized location and when effectively implemented, it is a useful tool to detect anomalous process conditions and indicate losses of SNM well before the scheduled physical inventory. If this methodology is used, the MC&A Plan shall describe:

- the methodology for division of processes into units for the detecting the loss of control of a significant quantity. The units shall be consistent with accessible measurements points that result from the process design. There is no limit or restriction on the number of units into which a process or facility can be divided.
- the material control tests used for detecting abrupt losses of bulk material from a single process unit, the loss detection capability, and the timeliness of the detection.
- the alarm threshold (critical value), which if exceeded initiates alarm resolution procedures.

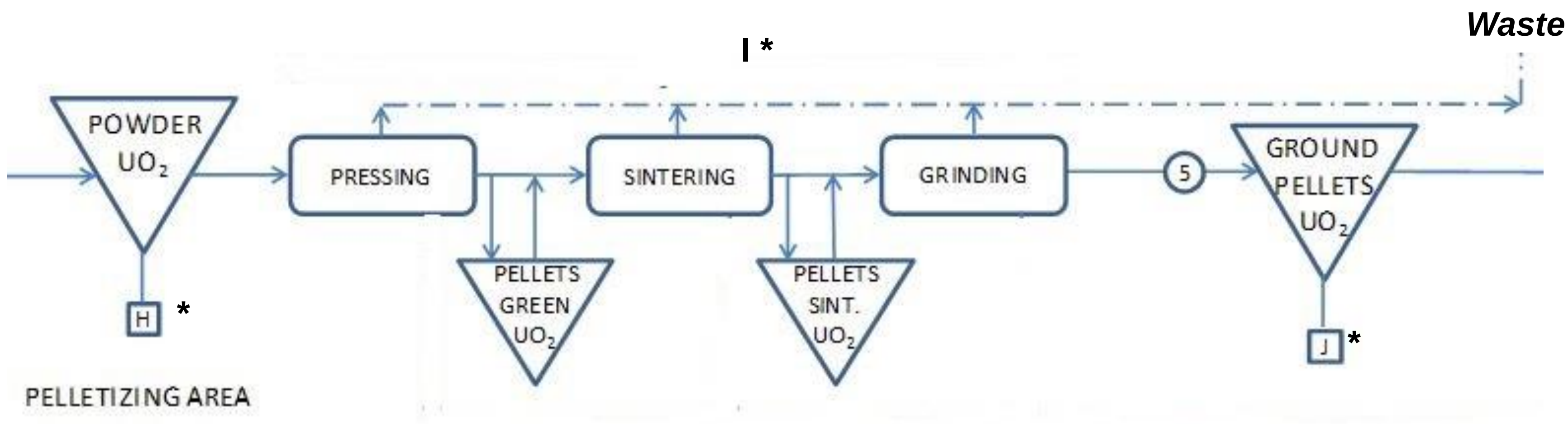
U.S. DOE Standard – DOE-STD-1194-2011 Chg 3– Nuclear Materials Control and Accountability, Paragraph 6.2.4.5 – Oct 2013

Hypothetical Facility – Bulk Processing Area

Pelletization Fabrication (8)



Pellet Fabrication Process (8)



*** H – KMP for UO2 powder – Gravimetric and Mass Spectrometry**
I – KMP for residual holdup – NDA Gamma
J – KMP for sintered pellets – scale and item verification.

<Class Discussion on options for application of process monitoring>

Reference: IAEA - Eugene V. Weinstock and Walter R. Kane. *STR-150 Detailed Description of an SSAC at the Facility Level for a Low-Enriched Uranium Conversion and Fuel Fabrication facility.* Report, Upton, NY: IAEA, 1984 (E. V. IAEA 1984)

Summary

- Discussed the affect of throughput on the detection capability of the Materials Accounting elements.
- Discussed different regulatory requirements in the area of MUF/ID evaluation
- Identified regulations and approaches that address and manage detection capability at higher throughputs
- Discussed options for hypothetical facility

Questions From Audience