Statistical Analysis of Glovebox Glove Failures in a Nuclear Facility

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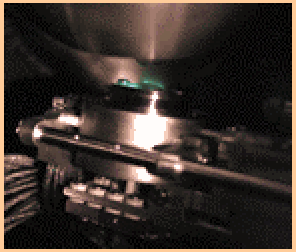
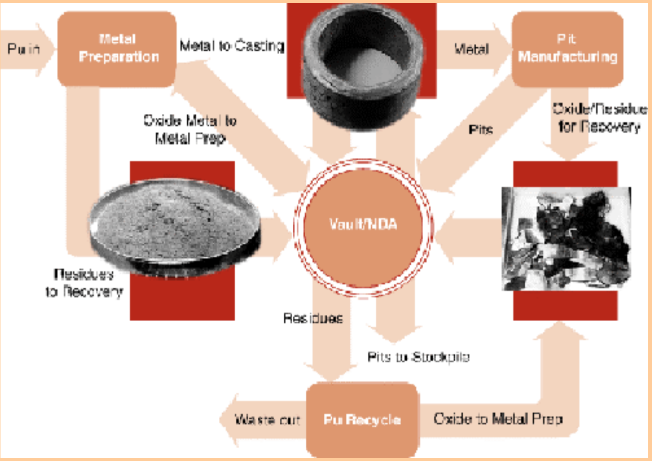
Abstract

- At the Los Alamos National Laboratory's Plutonium Facility, various isotopes of plutonium along with other actinides are routinely handled such that the spread of radiological contamination and excursions of contaminants into the operator's breathing zone are prevented through the use of a variety of gloveboxes The glovebox gloves are the weakest part of this engineering control. In this paper, data collected from scheduled glove changes was used to characterize service life intervals. We conclude that strong correlations between activities in aggressive radiation, corrosive, and mechanical environments have service life intervals of less than one year, long term service life intervals are less predictable, and gloves should be inspected more often and not arbitrarily changed.

Plutonium Facility Operations

- Actinide Process Chemistry
- Weapons Component Technology
- Plutonium-238 Science and Engineering
- Actinide and Fuel Cycle Technologies
- Pit Disposition Science and Technology
- Nuclear Materials Science

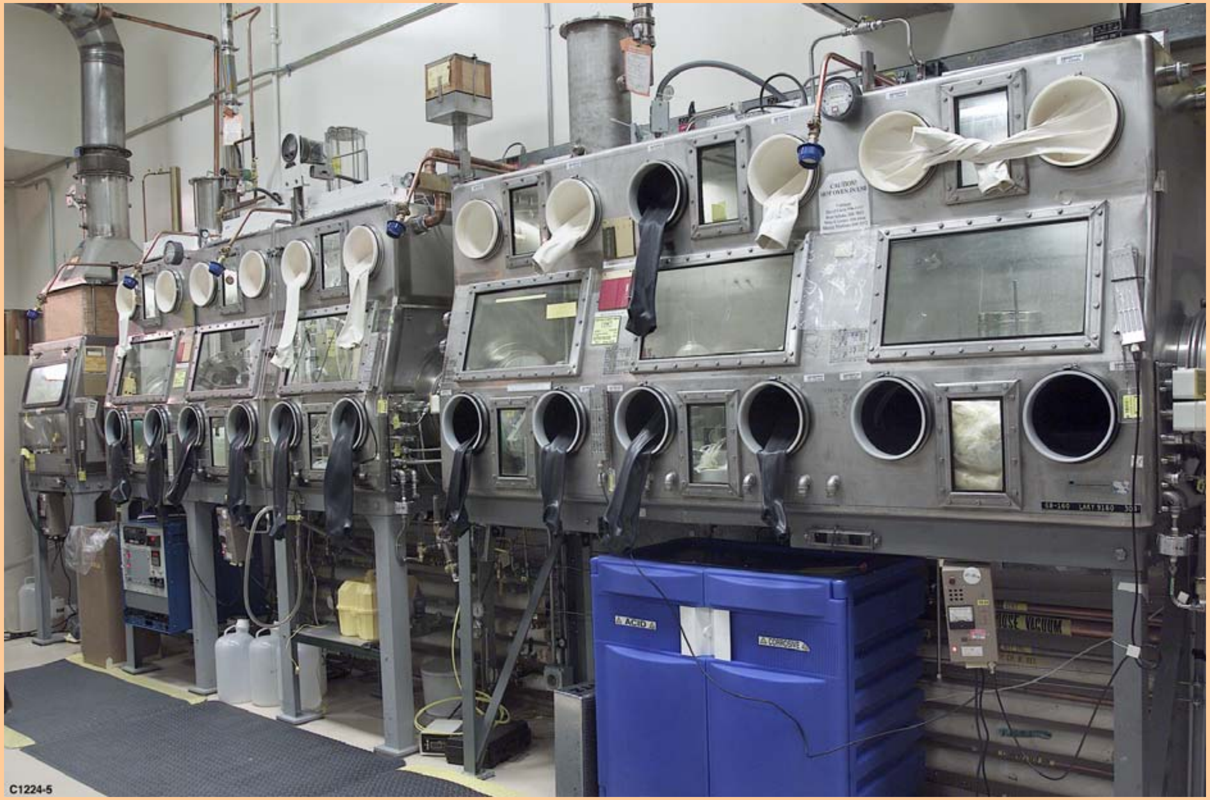




Plutonium Facility Hazards

Hazards		
Physical	**Chemical**	**Radiological**
Rotating Equipment	HCl Acid	Alpha
Sand Blasting	Nitric Acid	Beta
Welding Operations	Acids	Gamma
Thermal Sources	Bases	Neutrons
Grinding	Bromobenzene	
Sharps	Gas Permeability	
Pinch Points		

Typical Glovebox Train



Service Life Intervals

- 1 year for ^{238}Pu operations
- 2 year for ^{239}Pu operations
- A maximum of four extensions is allowed.

4.1 Install and Expiration Date Marking

When gloves are installed, they must be labeled with their install and expiration dates:

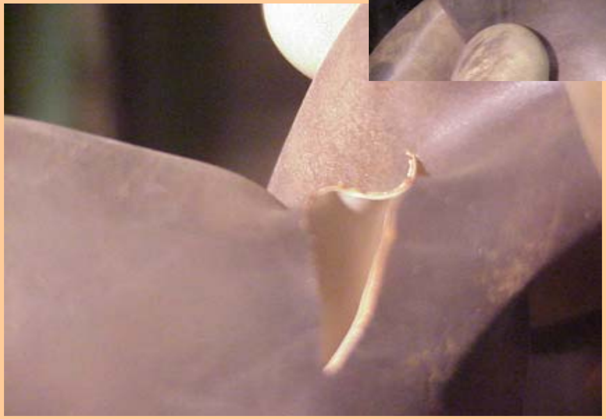
- Use the number format I mm/dd/yy for the install date (*the exact date of installation is needed because some gloves have failed in less than a month*). For example, a glove installed on July 16, 2007 should be marked I 07/16/07.
- Use the number format X mm/yy for the expiration date. For example, a glove that expires in July 2009 should be marked X 07/09.

Required standard inspection (service life) intervals for gloves are the following:

- ^{238}Pu operations: 1 year
- ^{239}Pu operations: 2 years

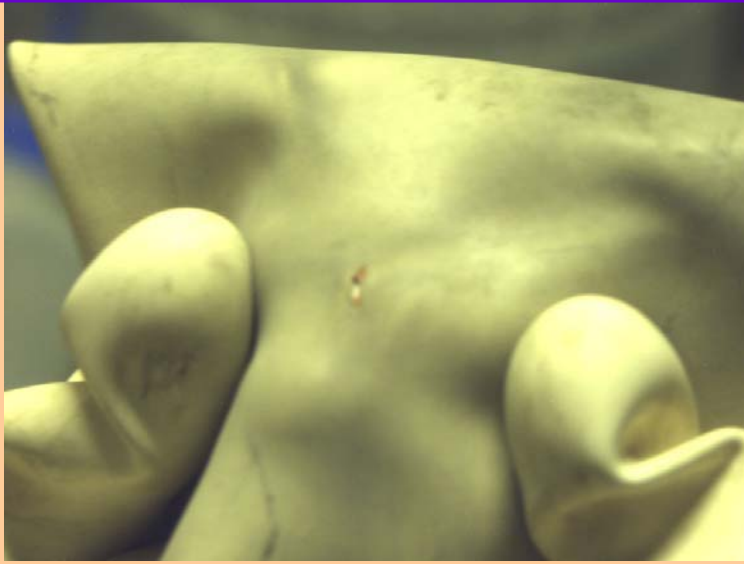
Glove Replacement

- Loss of integrity
- Glove failure
- Glove breach (one or more)



Loss of Integrity

- The glove has cracks, abrasions, dry-rot, brittle, discolored, or creased areas
- The glove requires change because of high beta/gamma readings



Glove Failures

- A glove failure is an opening in a glove caused by degradation of the mechanical properties over time, *e.g.*, exposure to chemicals and nuclear materials.
- The primary means of minimizing glove failures is through a robust glove inspection program that controls the inspection (service life) intervals for the gloves.

Glove Breaches

- A glove breach is an opening in a glove caused by mechanical damage during operations, *e.g.*, penetration with a sharp object; rotating equipment, pinch points, thermal sources, etc.
- The primary means of minimizing breaches is through administrative controls and Personal Protective Equipment (PPE). Chronic breaches arise from hazards related to aging.

Glove Changes & Inspections

Plutonium Facility Glove Inspection Data Record

General Information

	Inspection #1	Inspection #2	Inspection #3	Inspection #4	Inspection #5	Inspection #6
Group						
Room #						
Process						
Glovebox #						
Glove Port #						

Radiological Surface Survey (SAT/UNSAT)*

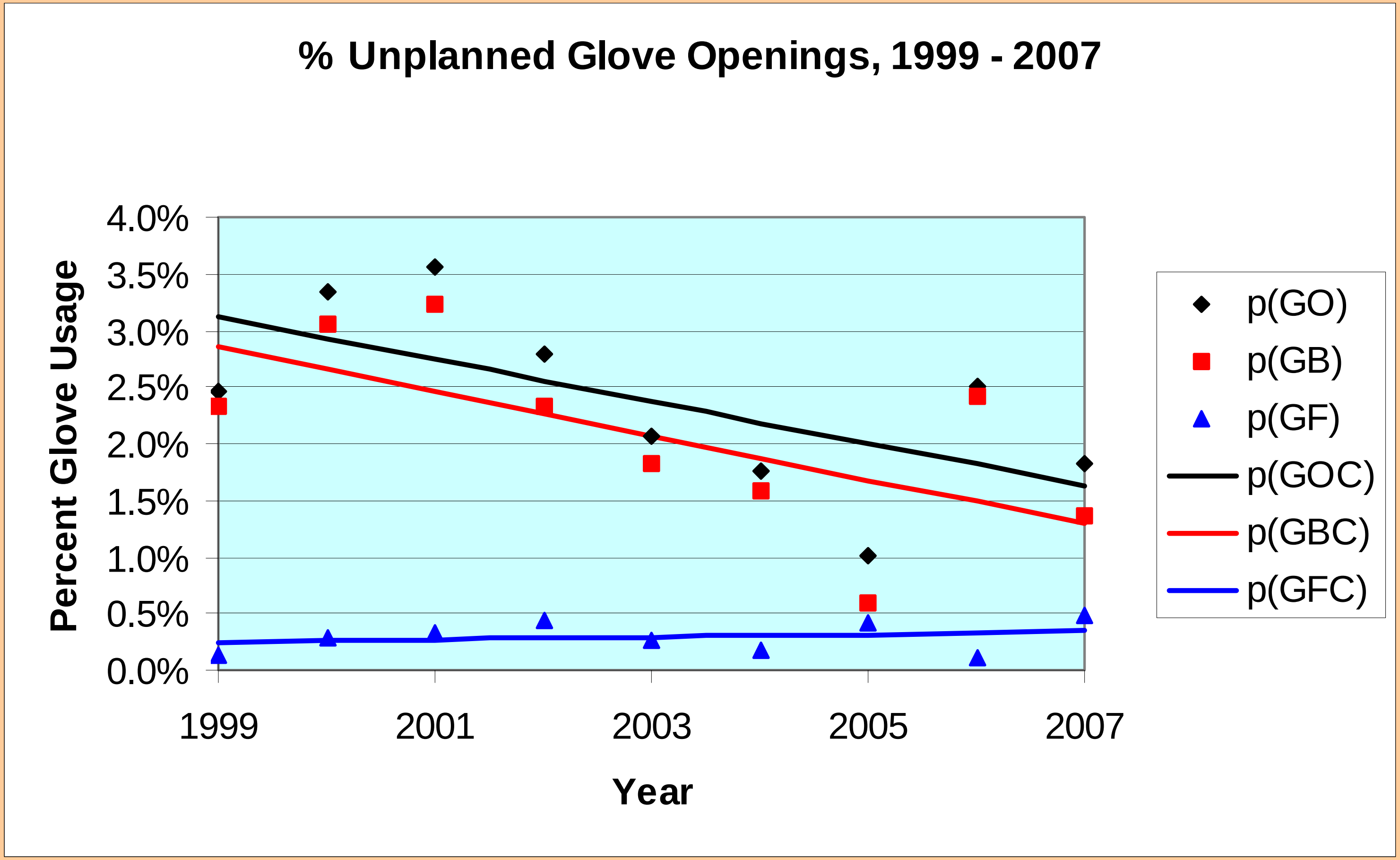
No signs of EXTERNAL surface radiological contamination						

Visual Inspection (SAT/UNSAT)*

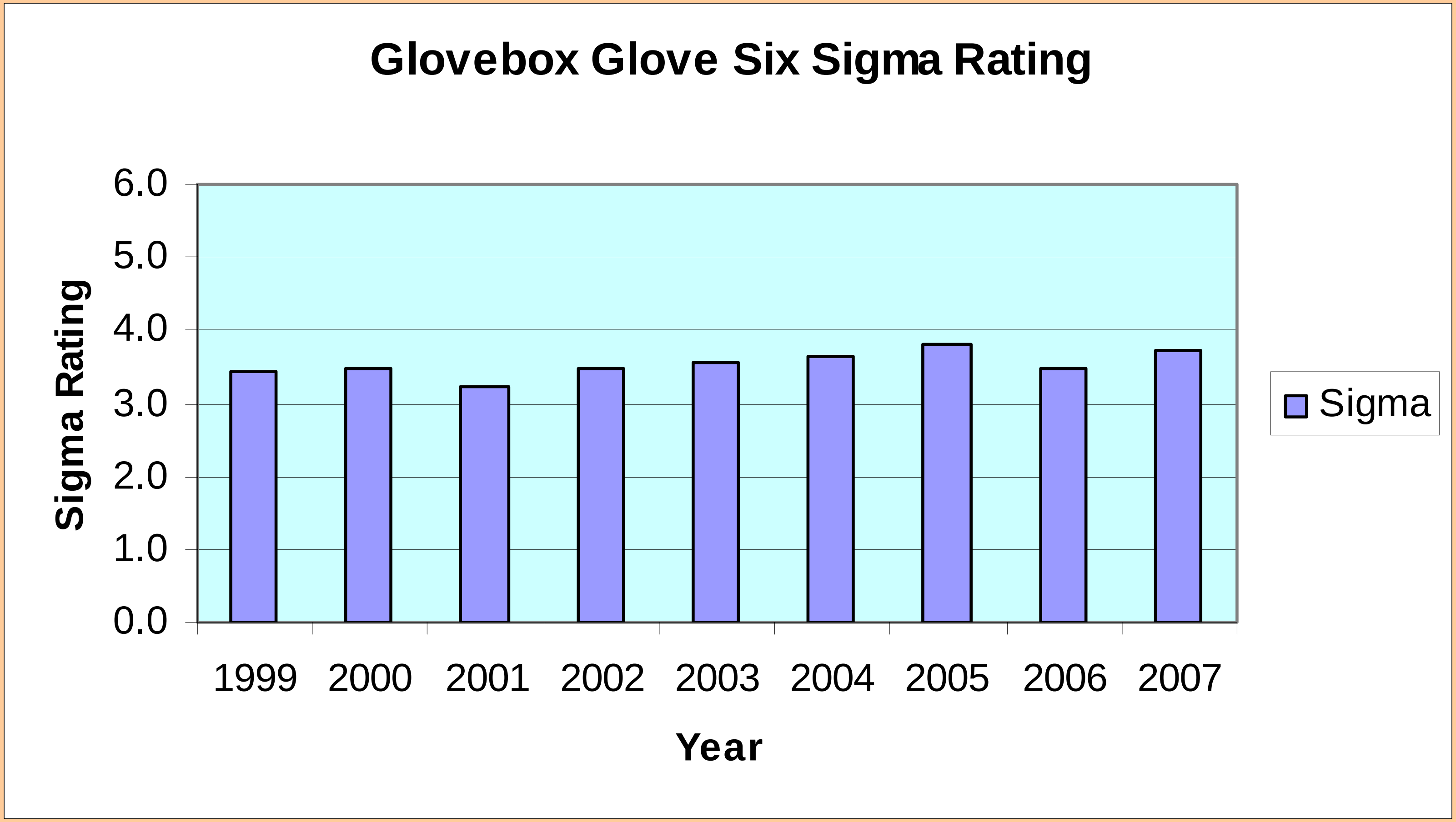
No signs of wear or degradation						
No exposed color from the lead liner						
No signs of cracking, thinning, or damage						
No signs of significant loss of dexterity						

*An UNSAT rating means the glovebox glove does not pass inspection.

Unplanned Openings



Six Sigma



Glovebox Glove Six Sigma Rating
Sigma Rating
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year
Sigma

Trending Data

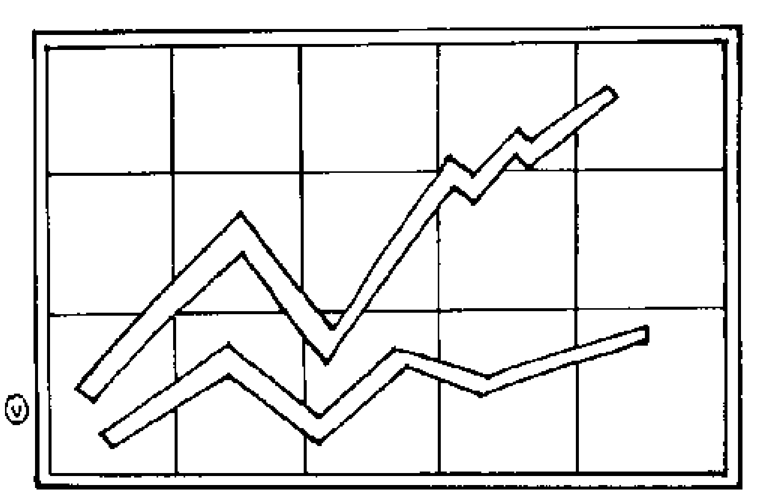
Glovebox	Pu Isotope	Activity	Service Life (months)
1	Pu-238	Scale	10.6
1	Pu-238	Scale	13.6
2	Pu-238	Ball Mill Prep	1.6
2	Pu-238	Ball Mill Prep	1.3
3	Pu-238	Slugging	1
3	Pu-238	Slugging	3.3
3	Pu-238	Slugging	1.6
4	Pu-238	Dropbox	5.4
4	Pu-238	Dropbox	4.5
5	Pu-238	Dropbox	4.7
5	Pu-238	Dropbox	2.6
6	Pu-238	Furnace	0.2
6	Pu-238	Furnace	0.4
7	Pu-238	Sieving Oxide	4.8
7	Pu-238	Sieving Oxide	0.6
8	Pu-239	HNO_3	4.7
9	Pu-239	HNO_3	3.7
10	Pu-239	Machining	2.2
11	Pu-239	Machining	7

Trending Data

Glovebox	Tier	Activity	Service Life (months)
1	Upper	Dropbox	102
2	Upper	Dropbox	142
3	Upper	Dropbox	180
4	Working	Dropbox	180
5	Working	Dropbox	181
6	Working	Foundry	180
7	Upper	HNO_3 Evaporation	142
8	Working	Ion Exchange	191
9	Working	Laser Welding	181
10	Lower	Machining	107
11	Upper	Machining	180
12	Working	Trolley	133
13	Upper	Trolley	197

Why Statistical Data Analysis?

- Data are only crude information and not knowledge by themselves
- The sequence from data to knowledge is
  - From Data to Information
  - From Information to Facts
  - From Facts to Knowledge



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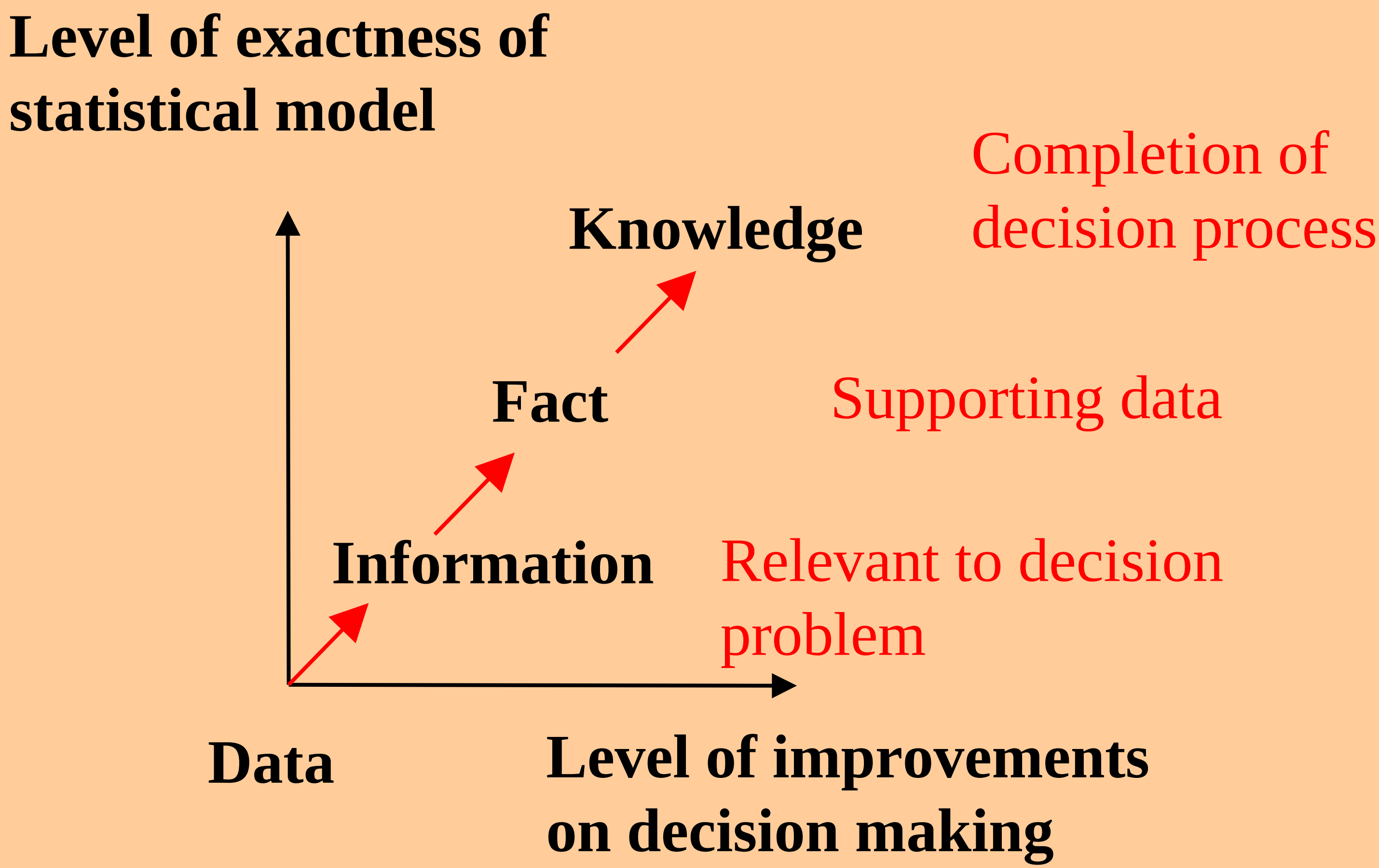
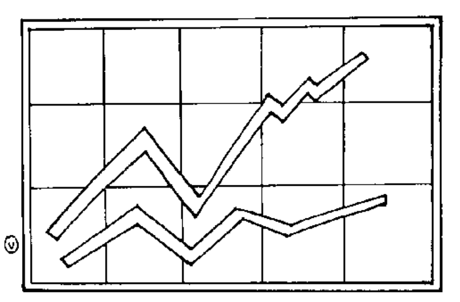
Why Statistical Data Analysis?



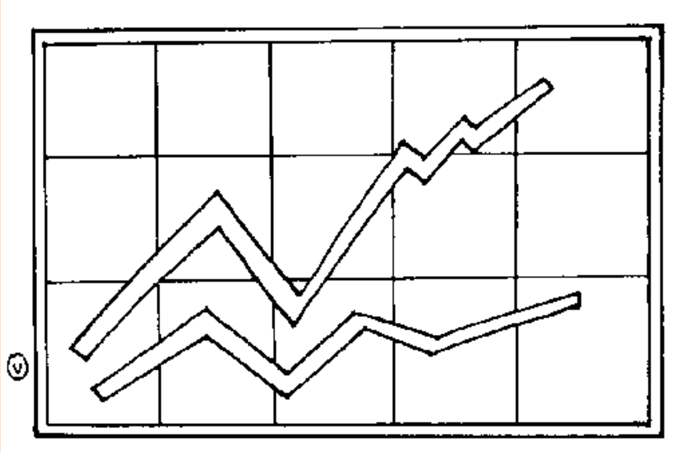
Discussion



- There is a strong correlation between short term glove service life intervals and the activity of the box
- Long term service life intervals are less predictable

Los Alamos

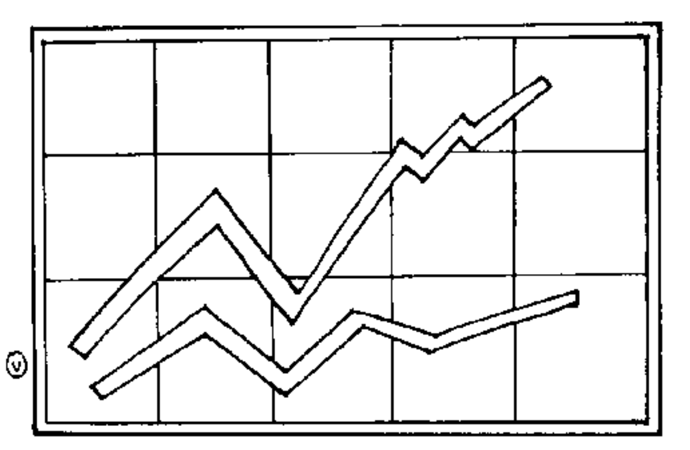
Discussion



- A glove change program was converted to more rigorous glove inspection program.
- Arbitrary change-out frequencies, may lead to the change-out of gloves that are still within specification.

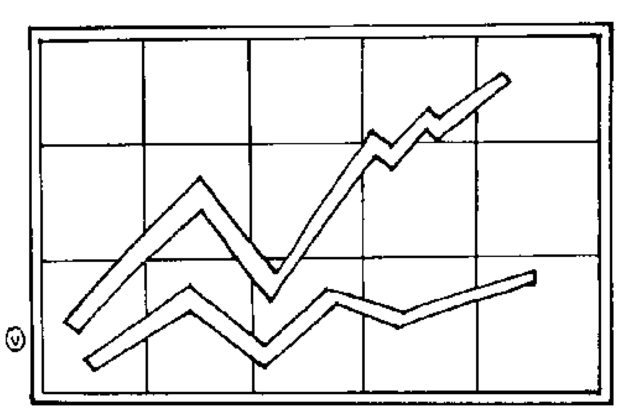
Discussion

- This increases waste generation and the possibility of a glove breach during installation.
- Approximately 4 m3/yr of TRU waste are generated from the disposal of glovebox gloves.



Discussion

- The results of this study will be used to modify glovebox glove inspection procedures
- More robust glove materials are need for Pu-238 operations



Conclusions

- Strong correlations between activities in aggressive radiation, corrosive, and mechanical environments have service life intervals of less than one year.
- Long term service life intervals are less predictable.
- Gloves should be inspected more often and not arbitrarily changed.

Acknowledgements

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