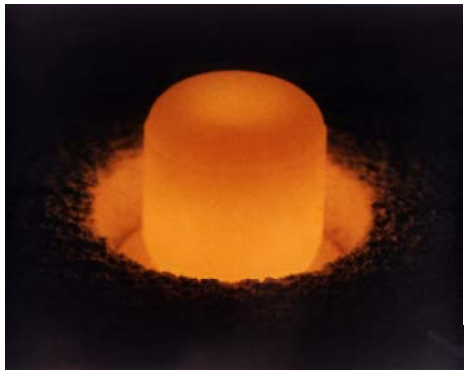
Fire Protection in Plutonium Facilities

2015 DOE Fire Safety Workshop

May 5-7, Alexis Park Hotel

EGS INC.
Empowered Global Solutions
Solving Our Partners Staffing Challenges

Agenda



- Introduction
- Plutonium Pyrophoricity
- Plutonium Burning Characteristics
- Past Events & Lessons Learned
- Moving Forward

About Me

Rob Plonski

- Undergrad in ME, UCCS
- Taurus
- Like long walks on the beach

About Me

Rob Plonski

Undergrad in Mechanical Engineering

Masters in Fire Protection Engineering

PE in NM

Los Alamos NATIONAL LABORATORY EST. 1943

(2009-2015)

Fire Protection Engineer

(Current)

Fire Protection Engineer

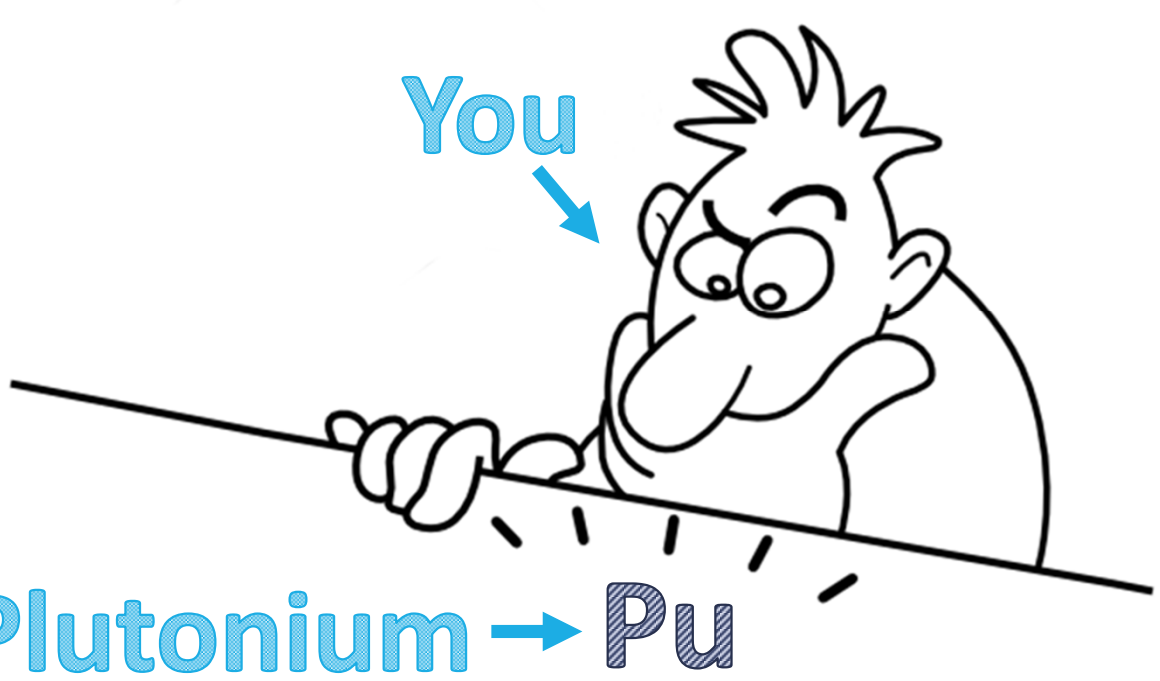
SRNL SAVANNAH RIVER NATIONAL LABORATORY Operated by Savannah River Nuclear Solutions, LLC

We Put Science To Work

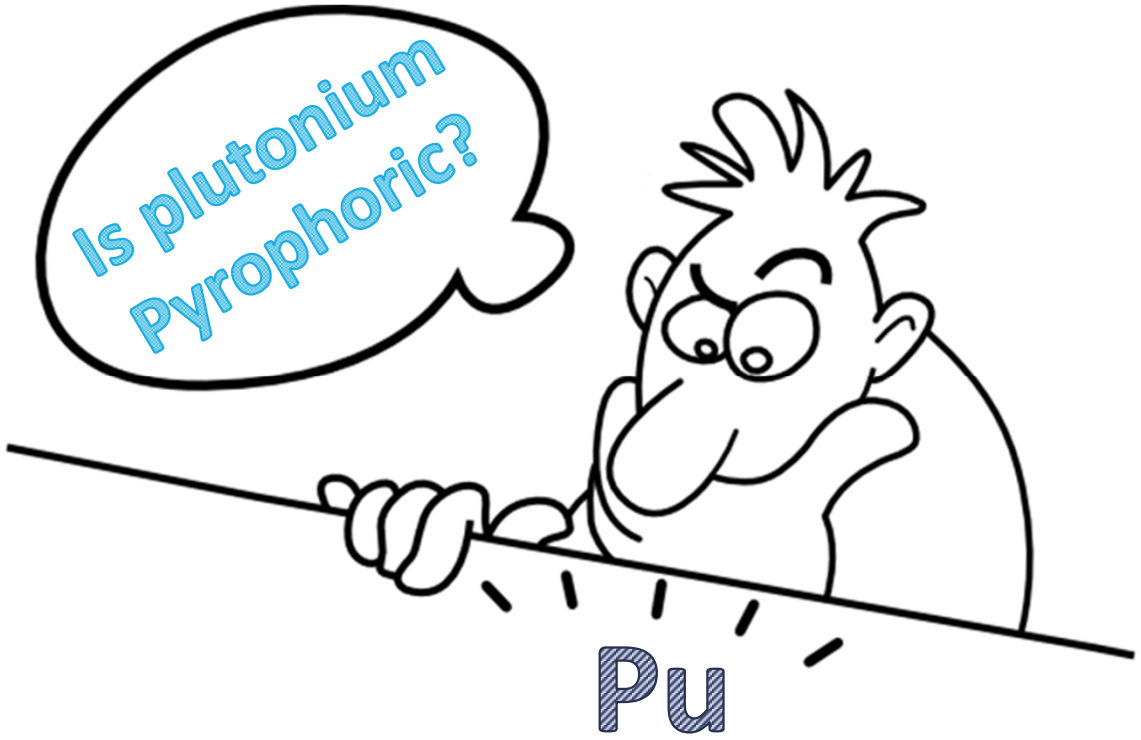
EGS INC. Empowered Global Solutions

Solving Our Partners Staffing Challenges

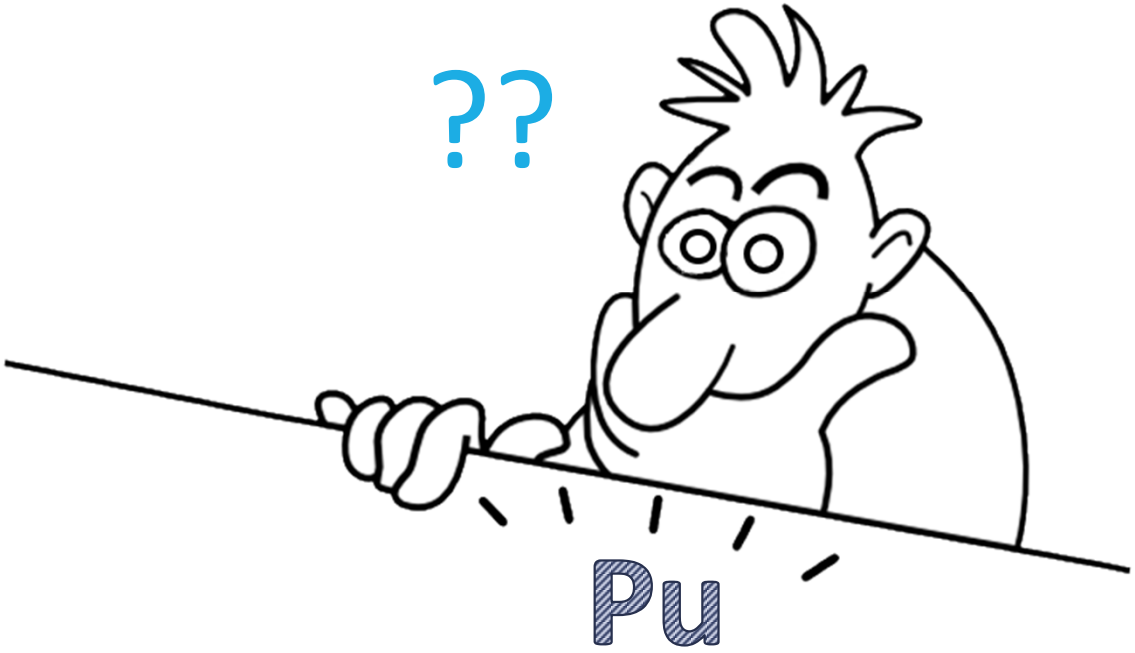
Plutonium (Pyrophoricity)



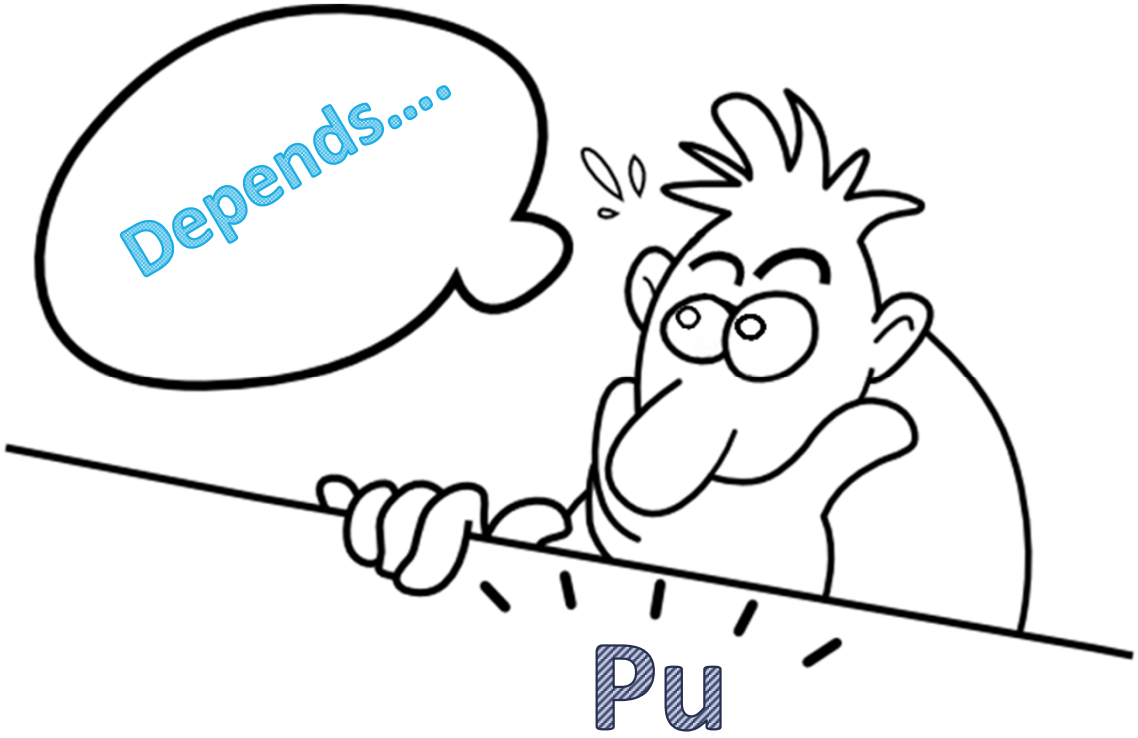
Plutonium (Pyrophoricity)



Plutonium Hazards (Pyrophoricity)



Plutonium (Pyrophoricity)



Plutonium (Pyrophoricity)

Plutonium (Pyrophoricity)

Plutonium (Pyrophoricity)

Size Matters

Plutonium (Pyrophoricity)

Powder

YES

Turnings/Shavings

Maybe

Ingots/Buttons

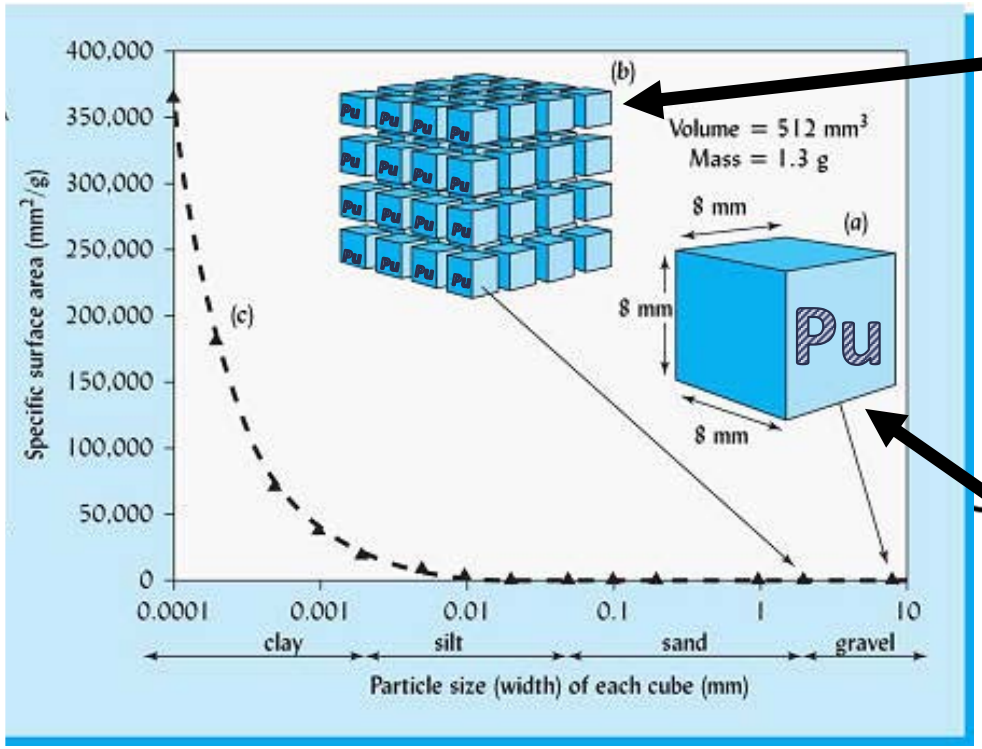
No

Plutonium (Pyrophoricity)

What Makes it Pyrophoric?

Specific Surface Area
VERY IMPORTANT

Plutonium (Pyrophoricity)



Mass: (0.02 g)

Surface Area (24 mm²)

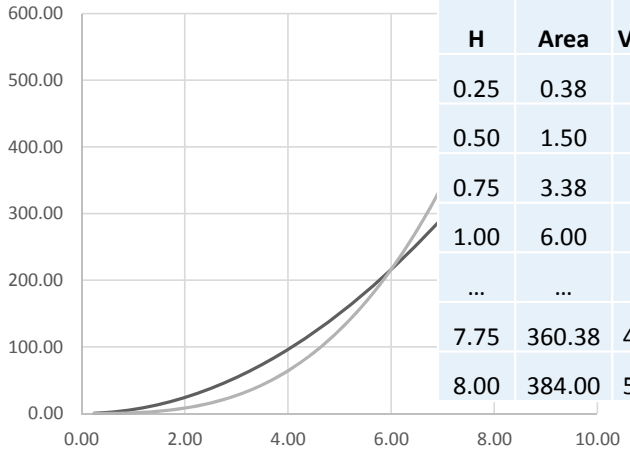
Specific Surface Area: 1,182 mm²/g

Mass: (1.3 g)

Surface Area (384 mm²)

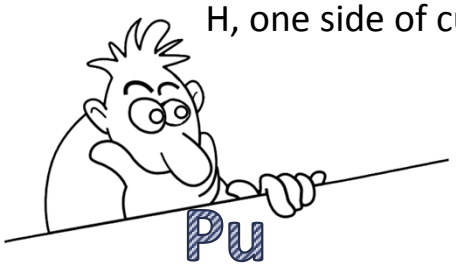
Specific Surface Area: 295 mm²/g

Plutonium (Burning Characteristics)



H	Area	Volume	Ratio (A/V)
0.25	0.38	0.02	24.00
0.50	1.50	0.13	12.00
0.75	3.38	0.42	8.00
1.00	6.00	1.00	6.00
...	...	...	...
7.75	360.38	465.48	0.77
8.00	384.00	512.00	0.75

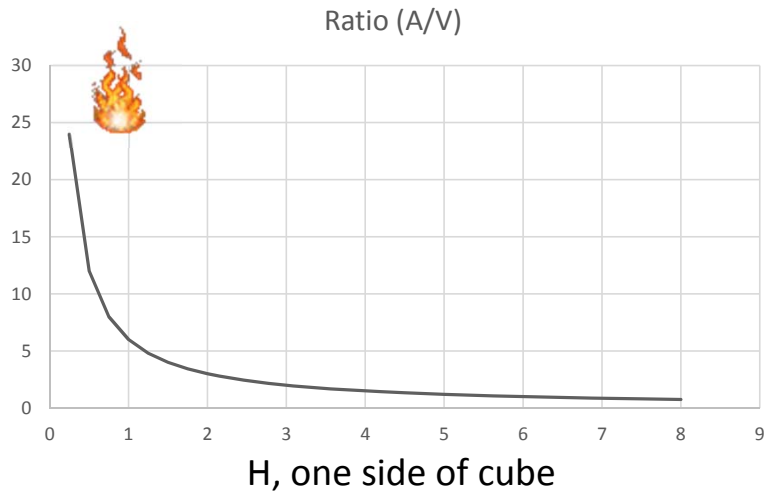
H, one side of cube



Remember

Area (cube) = $6h^2$ Therefore $\frac{dh}{dA} 6h^2 = 12h$

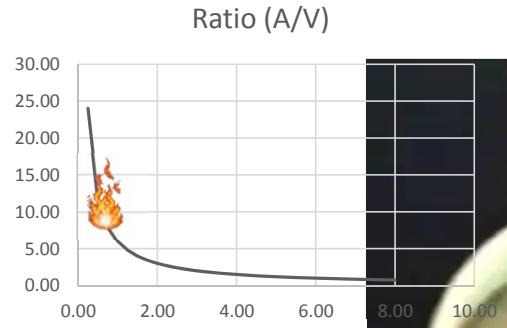
Vol (cube) = h^3 Therefore $\frac{dh}{dV} h^3 = 3h^2$



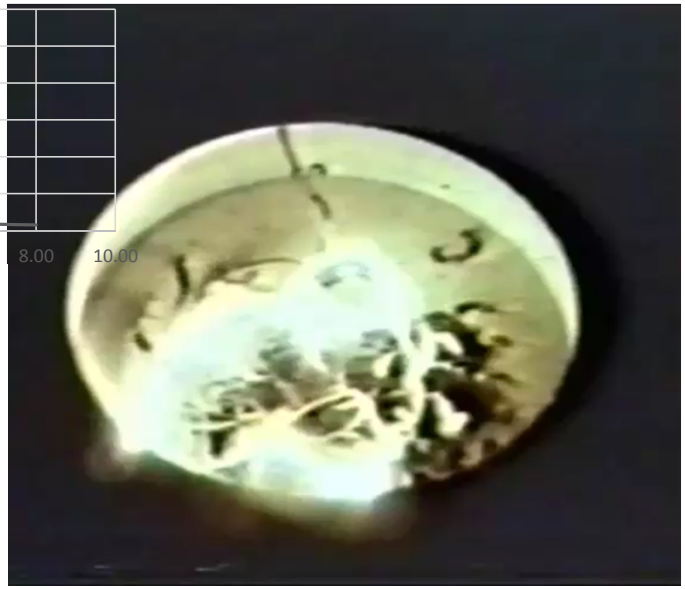
H, one side of cube

Plutonium (Burning Characteristics)

Powder or other Finely Divided State

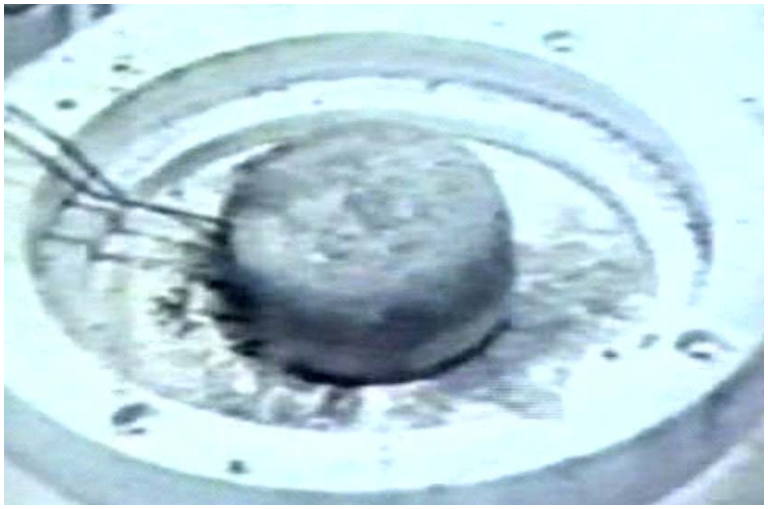


+ Air & Time



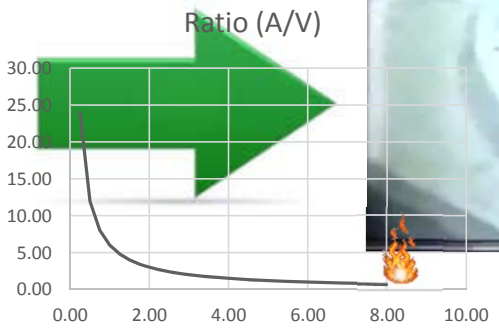
Powder or other Finely Divided State

Plutonium (Burning Characteristics)



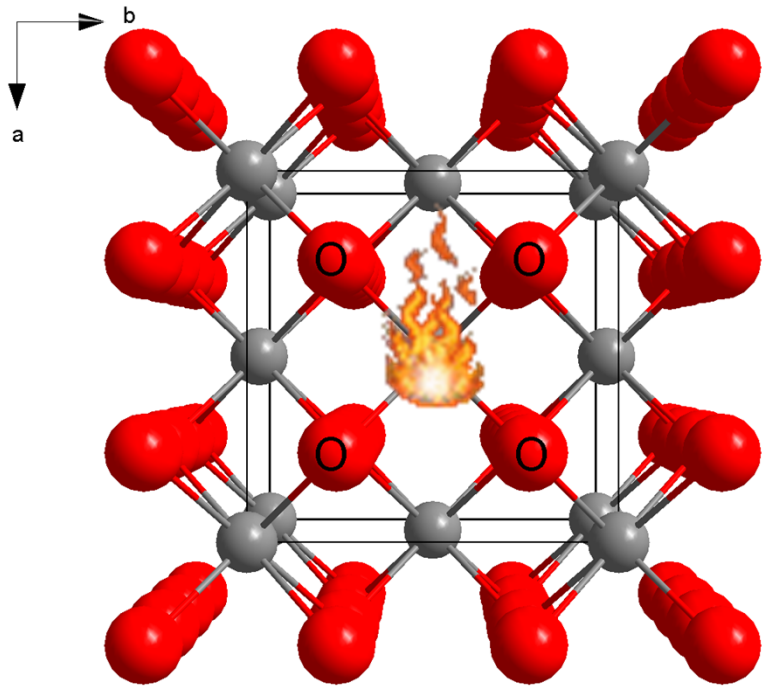
Button

+ Several minutes of intense heat

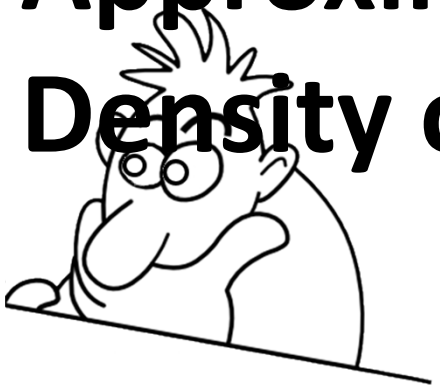


Button

Plutonium (Burning Characteristics)

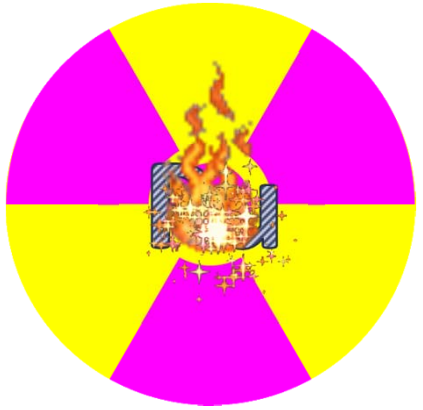


Approximately 1/3 Density of pure Pu

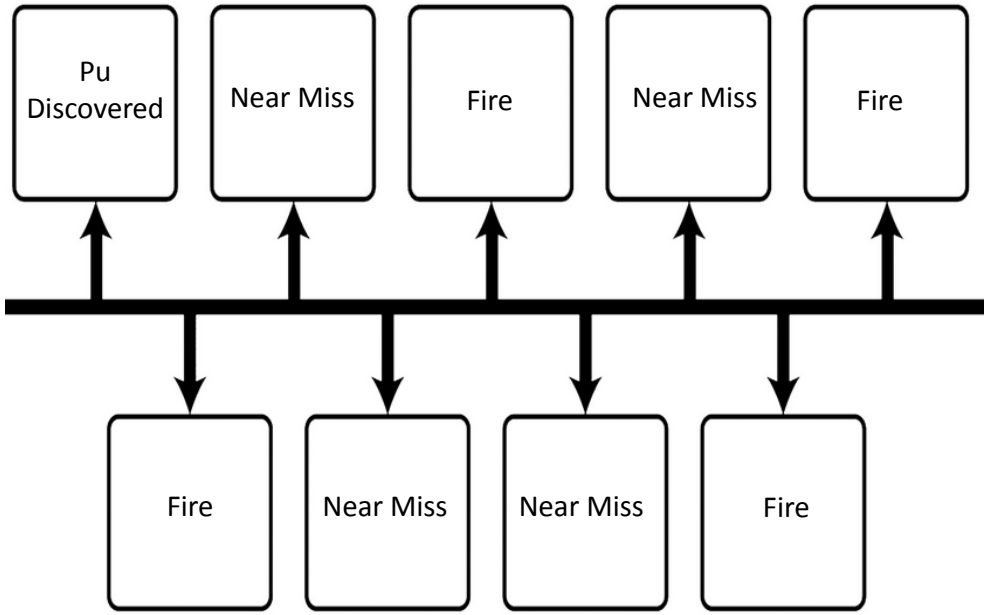


Plutonium (Burning Characteristics)

- Burning
  - Really Hot! (600°C)
- Little to No Flame
  - Can't see it burning?!
- Expanding
  - Becoming a bigger problem by the minute
- Molten
  - Disruption causes spewing & sparking
- Radioactive



Plutonium (Past Events)



We now understand how it burns…

Plutonium (Past Events)

Date: 1950's
Location: Los Alamos
Reference: http://library.lanl.gov/cgi-bin/getfile?23-05.pdf (pg 142)
Event: Near Miss
Plutonium buttons were stored in a freezer to keep the material cold so that it did not readily oxidize. In the morning on Monday, the operator went to retrieve a few buttons for casting and discovered that the freezer was not functioning and the plutonium had oxidized.

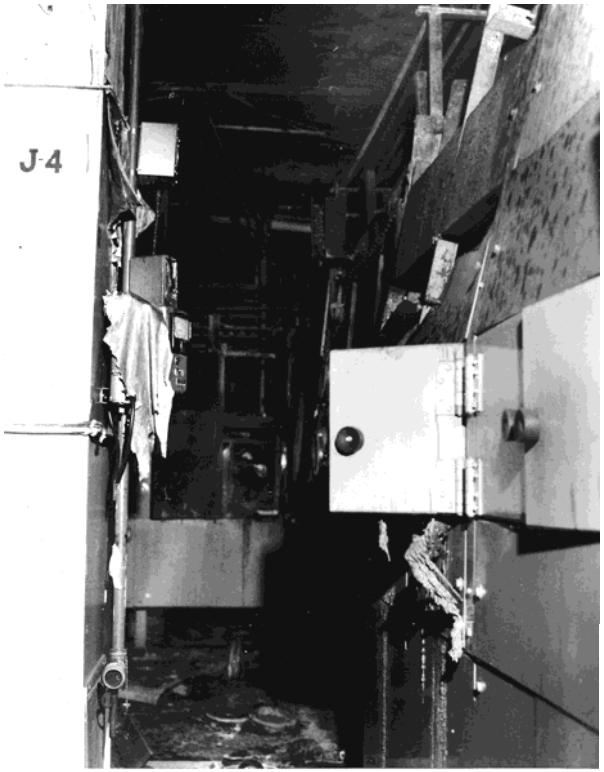
Plutonium (Past Events)

Date: 1957
Location: Rocky Flats
Reference: Https://www.colorado.gov/pacific/sites/default/files/HM_sf-rocky-flats-1957-fire.pdf
Event: Fire
A fire occurred in a plutonium handling glovebox, igniting a Plexiglas window and some of the glovebox gloves. The fire was attempted to be extinguished with a CO_2 fire extinguisher, but the efforts failed. The fire was eventually extinguished 12-hours after it has begun by the use of water.

Plutonium (Past Events)

Date: 1964
Location: Los Alamos
Reference: http://library.lanl.gov/cgi-bin/getfile?23-05.pdf (pg 144)
Event: Near Miss
Operator was removing the first glovebox created 25-gram button of Pu-238 from a furnace using tweezers. Upon taking the plutonium out of the furnace, the plutonium started sparking violently; the button was passed from operator to operator and dropped a few times before it was safely placed back into the furnace. The glovebox used was an air filled glovebox, which contributed to the rapid oxidation of the plutonium.

Plutonium (Past Events)



Date: 1969
Location: Rocky Flats
Reference: https://www.colorado.gov/pacific/sites/default/files/HM_sf-rocky-flats-1969-fire.pdf
Event: Fire

Plutonium stored in an open can within a glovebox spontaneously ignited. Plastics within the glovebox, gloves, and plastic shielding added to fire. The fire was eventually contained almost five-hours after it had begun. It took an additional two hours to extinguish the fire by use of water. During the firefighting operation, a deflagration took place in one of the HEPA filter plenums; the cause of the deflagration is under debate, but is most likely attributed to hydrogen gas buildup from the plutonium oxidation with water in an oxygen deficient environment.

Plutonium (Past Events)

Date: 1980's
Location: Los Alamos
Reference: http://library.lanl.gov/cgi-bin/getfile?23-05.pdf (pg 144)
Event: Near Miss
During a plutonium redox process using a pressure vessel within the Los Alamos Plutonium Facility, the pressure vessel came apart, causing a 4-inch hole in the bottom of the glovebox. The operator saw sparks and held wet cheesecloth at the glove ports to keep the gloves from igniting. Due to the negative pressure form the attached ventilation, this event was contained entirely within the glovebox.

Plutonium (Past Events)

Date: 1993
Location: Los Alamos
Reference: ORPS Report ALO-LA-LANL-TA55-1993-0039
Event: Near Miss
Failure of a storage container allowed plutonium to oxidize, expand to approximately 150% its original volume, rupture the inner storage vessel, and become noticeably warm to the touch. Expansion and oxidation ceased after the container was transferred to an argon atmosphere.

Plutonium (Past Events)

Date: 1995
Location: Los Alamos
Reference: Report ALO-LA-LANL-TA55-1995-0002
Event: Fire
Plutonium alloy oxide within a glovebox fell onto a terry cloth that then produced sparks and flames. The operator picked up the burning terry cloth with the glovebox glove, crumpled it, placed the smoldering cloth into an adjacent transfer chamber and flooded it with nitrogen, extinguishing the fire.

Plutonium (Lessons Learned)

1950's Los Alamos(Near Miss)
- Don't store Pu in air, even if in a freezer

1957, Rocky Flats (Fire)
- CO_2 Extinguishers don't work on Pu

1964, Los Alamos (Near Miss)
- Don't handle Pu from a furnace in an air glovebox

1969, Rocky Flats (Fire)
- Water can be effective on Pu fires, but significant hydrogen buildup/deflagrations can occur

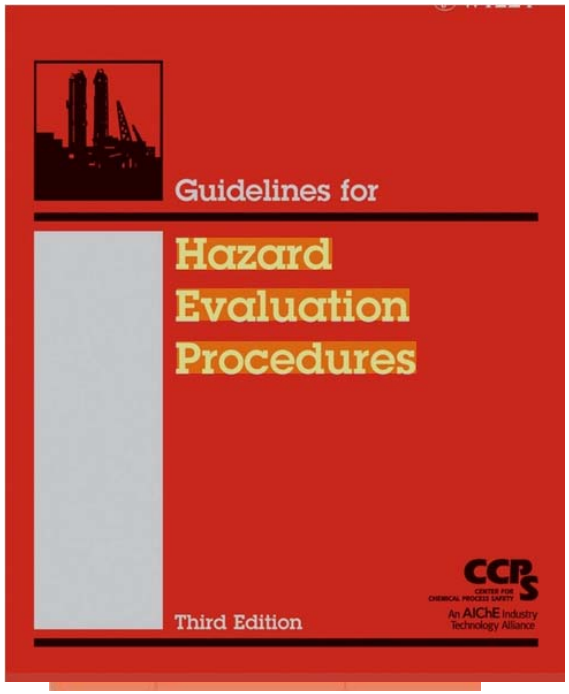
1980's, Los Alamos (Near Miss)
- Anticipate and understand pressure-induced confinement failures

1993, Los Alamos (Near Miss)
- Ensure storage containers are regularly inspected and understand the signs of a failing container

1995, Los Alamos (Fire)
- Minimize/eliminate organics near Pu; rapid operator response can prevent a large event

Plutonium (Moving Forward)

- Thorough Hazards Analysis



C.2 HAZARD CHECKLIST FOR ENERGY SOURCES

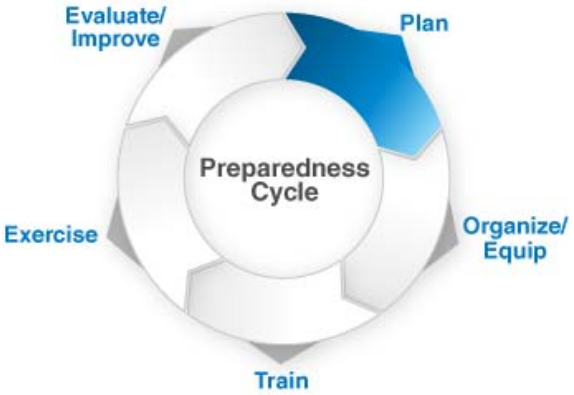
This checklist is a general list of potentially hazardous energy sources. A system that uses any of these energy sources will very likely have various associated hazards. This checklist was collected by C. Ericson.

1. Fuels
2. Propellants
3. Initiators
4. Explosive charges
5. Charged electrical capacitors
6. Storage batteries
7. Static electrical charges
8. Pressure containers
9. Spring-loaded devices
10. Suspension systems
11. Gas generators
12. Electrical generators
13. Radio frequency energy sources
14. Radioactive energy sources
15. Falling objects
16. Catapulted objects
17. Heating devices
18. Pumps, blowers, fans
19. Rotating machinery
20. Actuating devices
21. Nuclear

Figure 1.2 *Closed-loop*

Plutonium (Moving Forward)

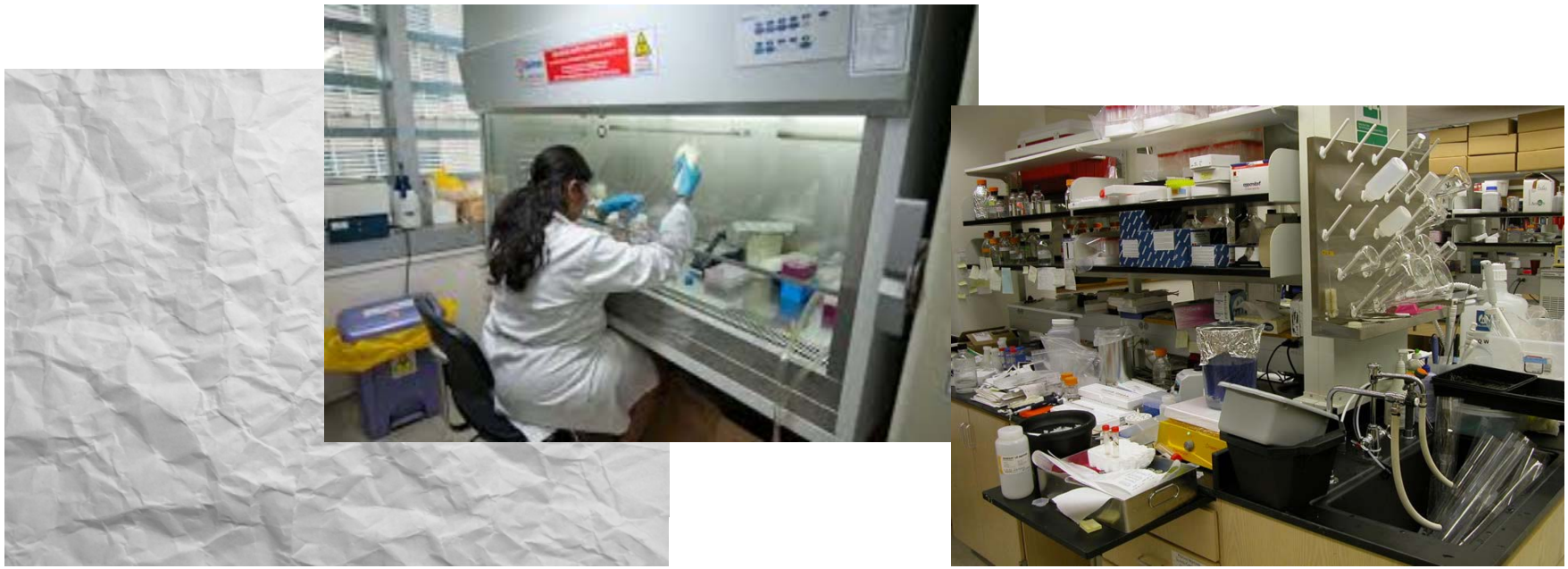
- Emergency Planning/Preparedness
  - Scenario development
  - Operator Response
  - Emergency Response



NFPA 1600: Standard on Disaster/Emergency Management and Business Continuity Programs

Plutonium (Moving Forward)

- Manage Combustibles/Housekeeping



Plutonium (Moving Forward)

- Have the appropriate type and quantity of suppressant on hand

CLASSES OF FIRES	TYPES OF FIRES	PICTURE SYMBOL
A	Wood, paper, cloth, trash & other ordinary materials.	
B	Gasoline, oil, paint and other flammable liquids.	
C	May be used on fires involving live electrical equipment without danger to the operator.	
D	Combustible metals and combustible metal alloys.	D
K	Cooking media (Vegetable or Animal Oils and Fats)	

Plutonium (Moving Forward)

Inspections

Walkdowns

Field Verifications

Get into facilities
to
Ask questions
to
Verify information
and
Understand the conditions

Plutonium (Recap)

- **What makes plutonium burn**
  - **Specific surface area, temperature, oxygen**
- **How plutonium burns & hazards**
  - **Hot, expanding, sparking, flowing, radioactive**
- **Past plutonium fire events and near misses**
  - **Los Alamos, Rocky Flats, Savannah River, Lawrence Livermore**
- **Lessons learned**
  - **Pu reactions in air, hydrogen production, container storage**
- **Moving forward**
  - **Hazards analyses, emergency preparedness, managing combustibles, extinguishments, inspections**

Questions?

Topic: Fire Protection in Plutonium Facilities
Presenter: Rob Plonski
Contact: RobPlonski@YourFPE.com

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Extinguishing Pu Fires

VIDEO HERE