

# Fire Protection in Plutonium Facilities

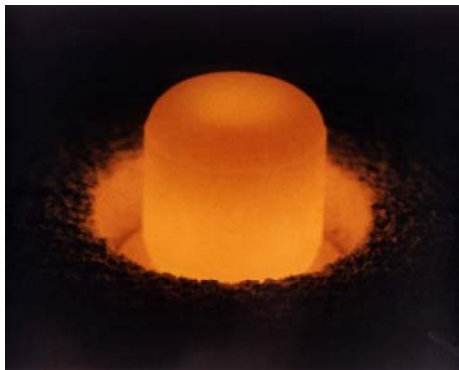
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2015 DOE Fire Safety Workshop  
May 5-7, Alexis Park Hotel



# Agenda

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

# About Me

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Rob Plonski


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

# About Me

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Rob Plonski 

Undergrad in Mechanical Engineering 

Masters in Fire Protection Engineering 

PE in NM 



(2009-2015)  
Fire Protection Engineer

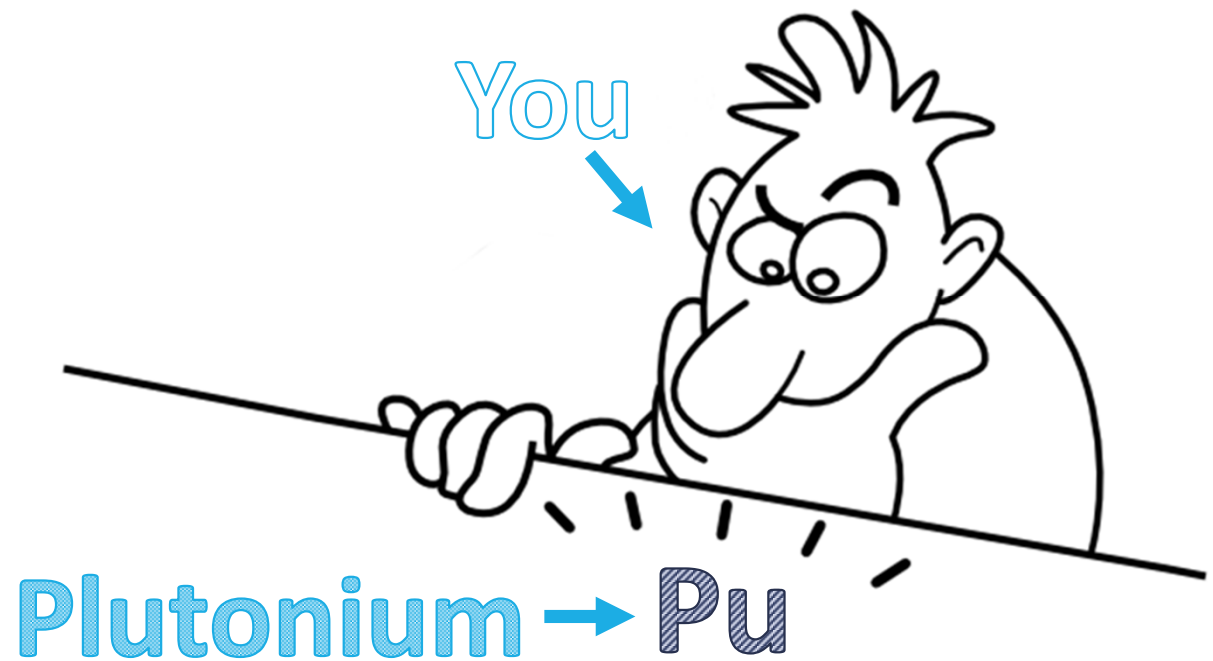
(Current)

Fire Protection Engineer



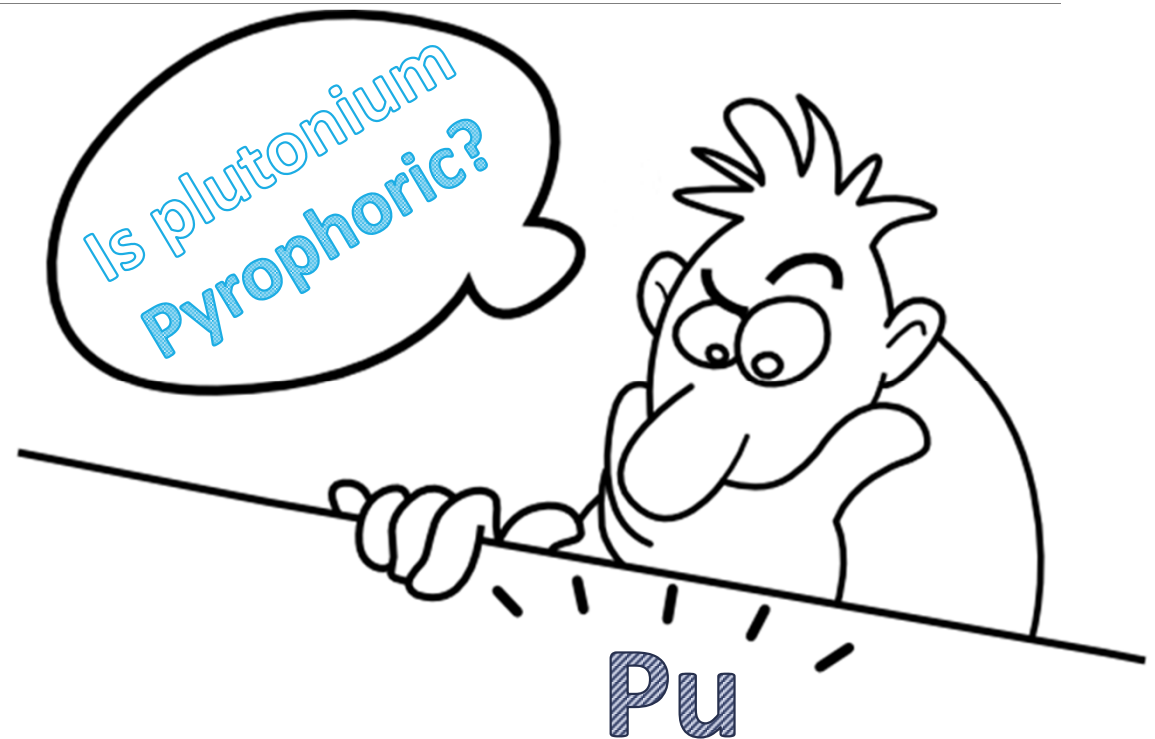
# Plutonium (Pyrophoricity)

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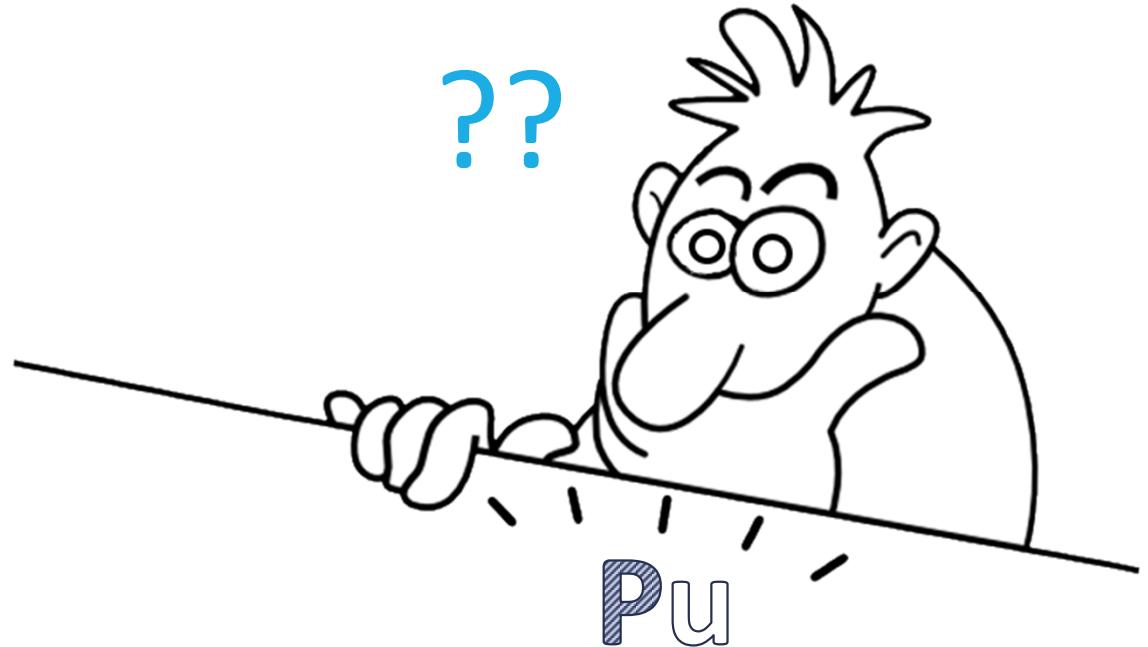
# Plutonium (Pyrophoricity)

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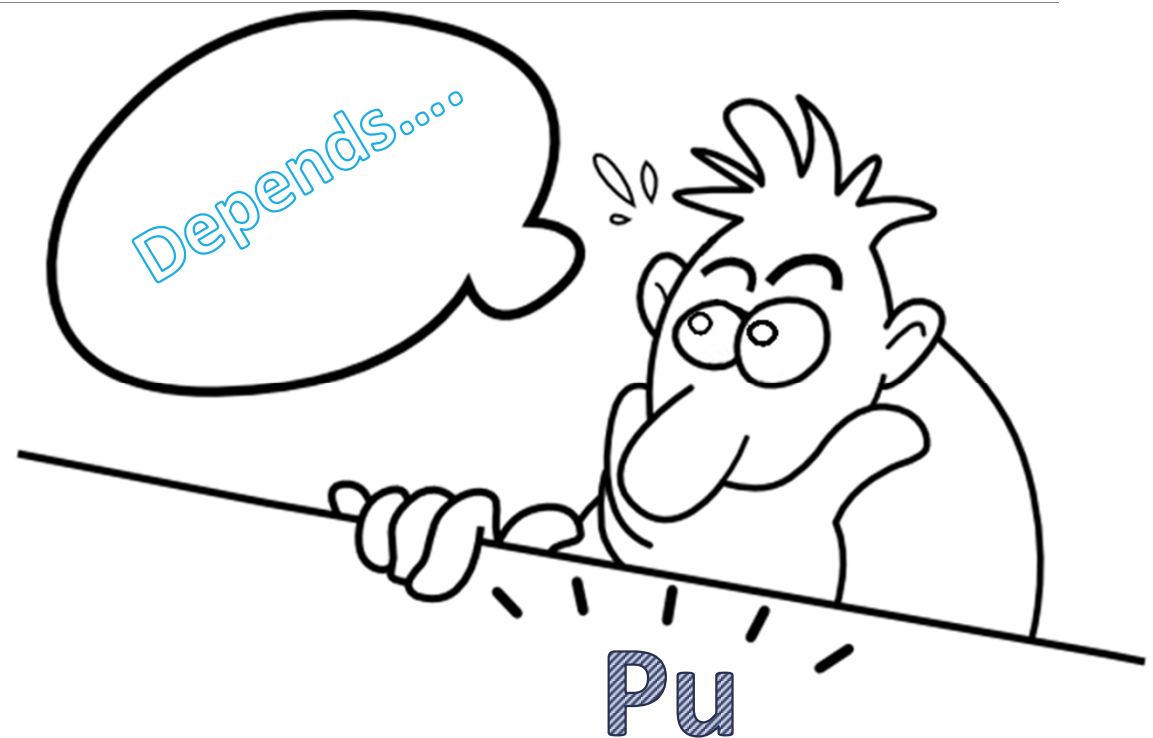
# Plutonium Hazards (Pyrophoricity)

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# Plutonium (Pyrophoricity)

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# Plutonium (Pyrophoricity)

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# Plutonium (Pyrophoricity)

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# Plutonium (Pyrophoricity)

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## Size Matters



# Plutonium (Pyrophoricity)

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Powder



**YES**

Turnings/Shavings



**Maybe**

Ingots/Buttons



**No**

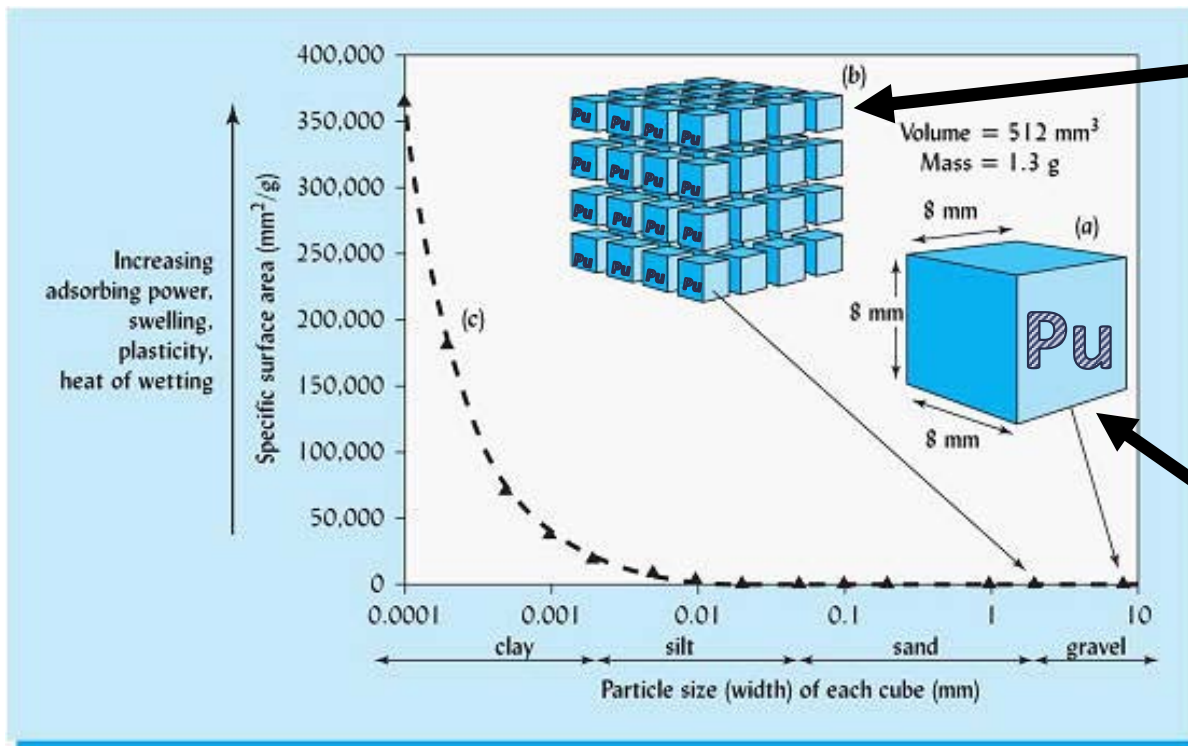
# Plutonium (Pyrophoricity)

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What Makes it Pyrophoric?

Specific Surface Area  
**VERY IMPORTANT**

# Plutonium (Pyrophoricity)



Mass: (0.02 g)

Surface Area (24  $\text{mm}^2$ )

Specific Surface Area:

**1,182  $\text{mm}^2/\text{g}$**

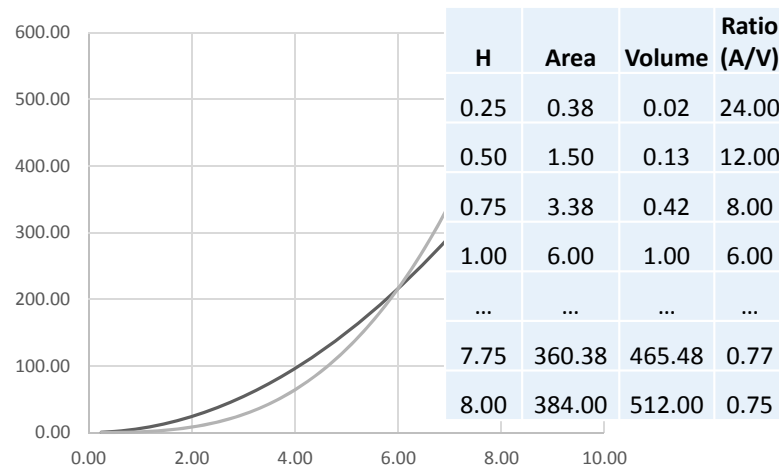
Mass: (1.3 g)

Surface Area (384  $\text{mm}^2$ )

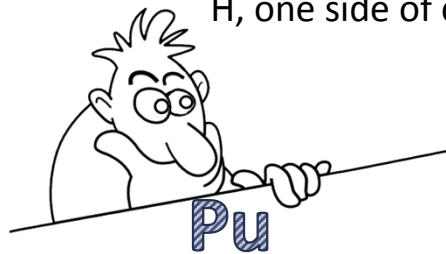
Specific Surface Area:

**295  $\text{mm}^2/\text{g}$**

# Plutonium (Burning Characteristics)



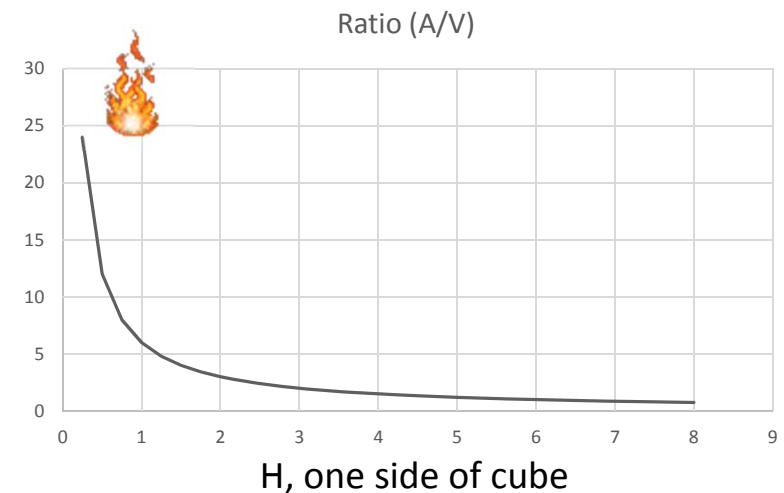
H, one side of cube



Remember

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

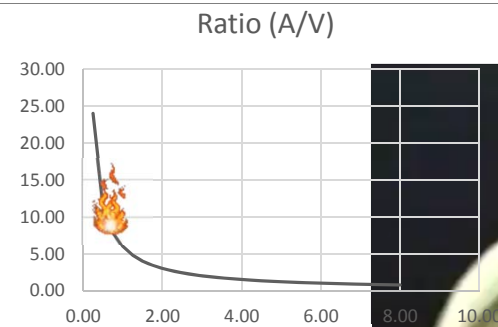
Vol (cube) =  $h^3$  Therefore  $\frac{dh}{dV} h^3 = 3h^2$



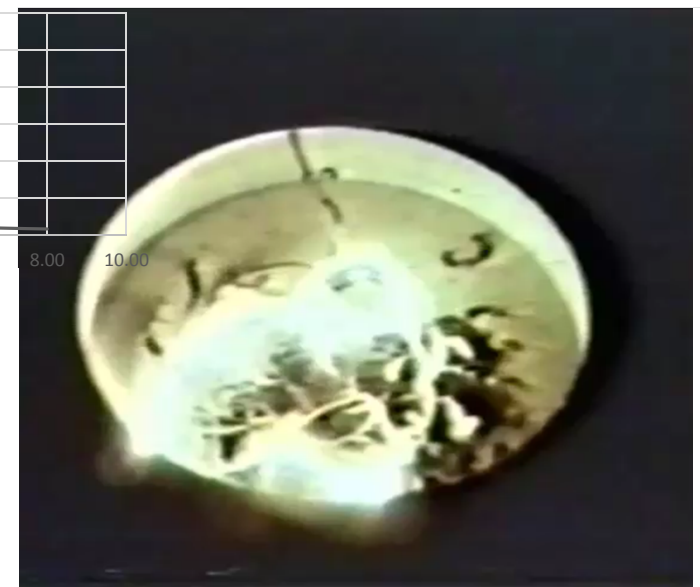
# Plutonium (Burning Characteristics)



Powder or other Finely Divided State



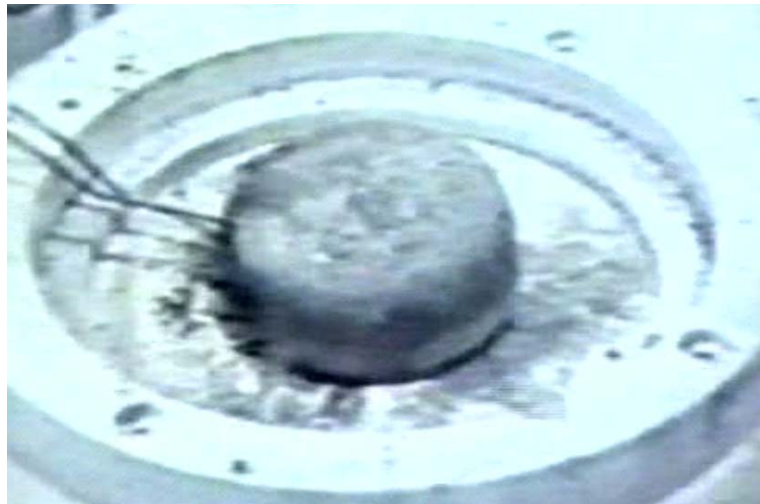
+ Air & Time



Powder or other Finely Divided State

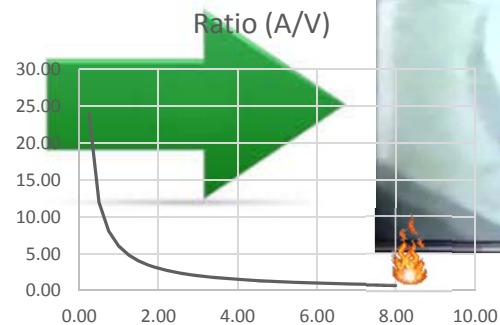


# Plutonium (Burning Characteristics)



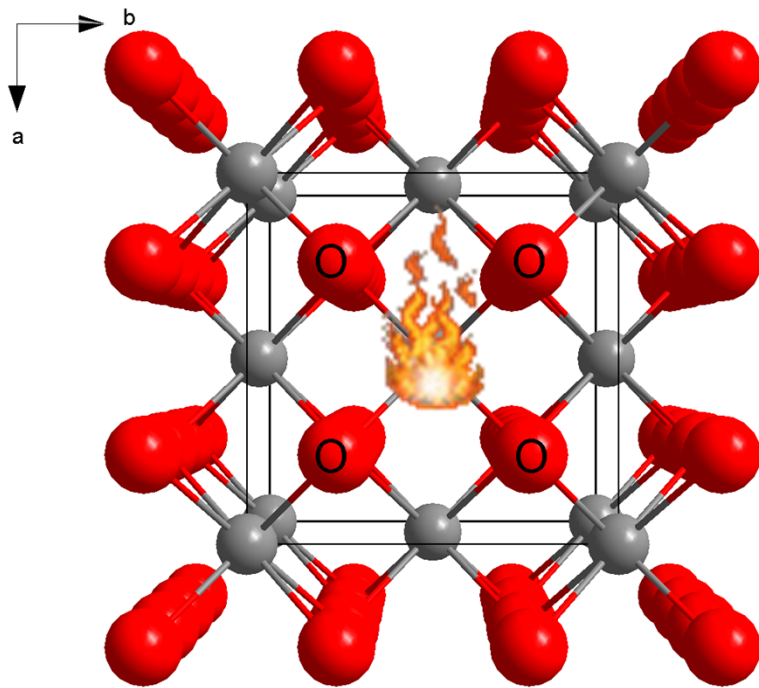
Button

+ Several minutes of intense heat

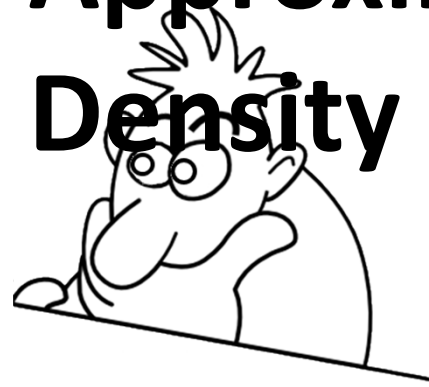


Button

# Plutonium (Burning Characteristics)



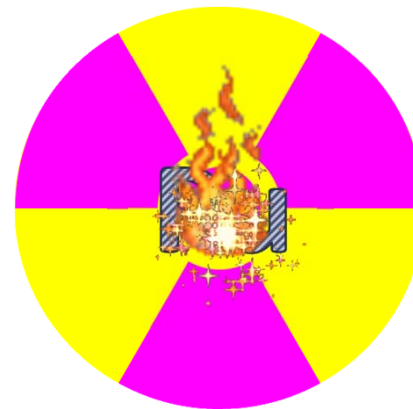
**Approximately 1/3  
Density of pure Pu**



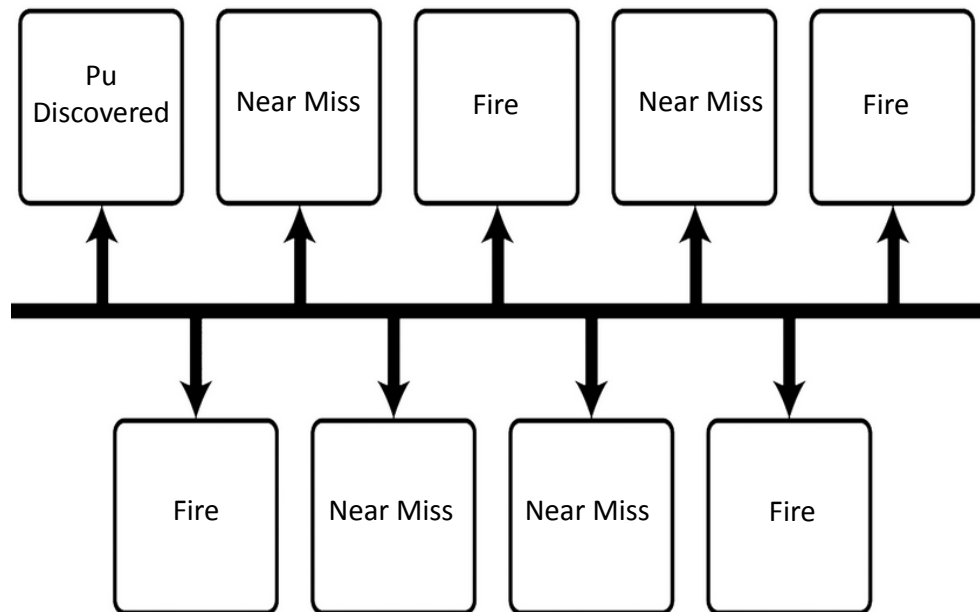
# Plutonium (Burning Characteristics)

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- 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)

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**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)

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**Date:** 1957

**Location:** Rocky Flats

**Reference:** [https://www.colorado.gov/pacific/sites/default/files/HM\\_sf-rocky-flats-1957-fire.pdf](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<sub>2</sub> 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)

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**Date:** 1964

**Location:** Los Alamos

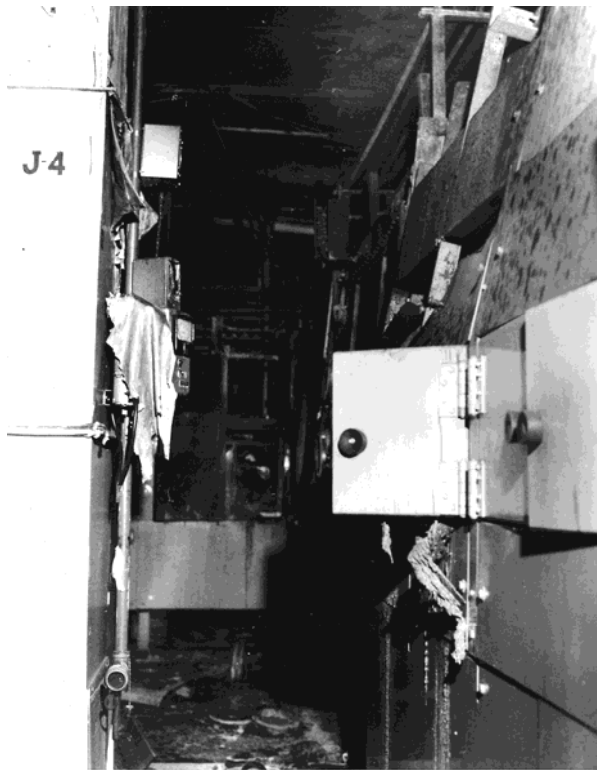
**Reference:** <http://library.lanl.gov/cgi-bin/getfile?23-05.pdf> (pg 144)

**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](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)

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**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 from the attached ventilation, this event was contained entirely within the glovebox.

# Plutonium (Past Events)

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**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)

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**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)

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## 1950's Los Alamos (Near Miss)

- Don't store Pu in air, even if in a freezer

## 1957, Rocky Flats (Fire)

- CO<sub>2</sub> 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)

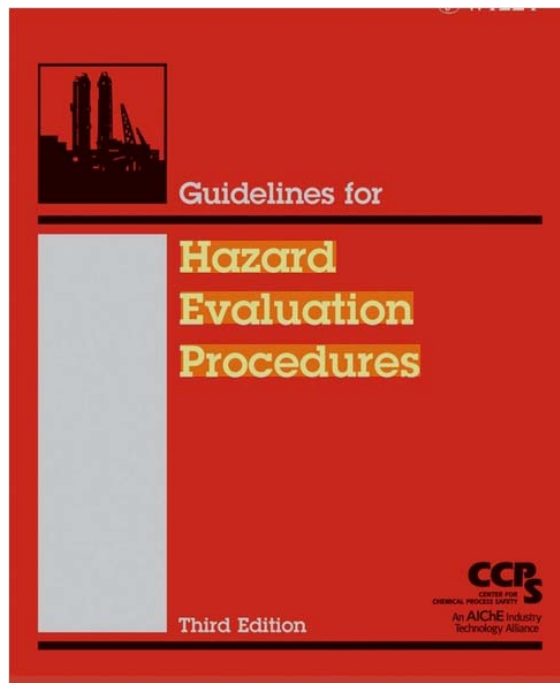
- Ensure storage containers are regularly inspected and understand the signs of a failing container

## 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.

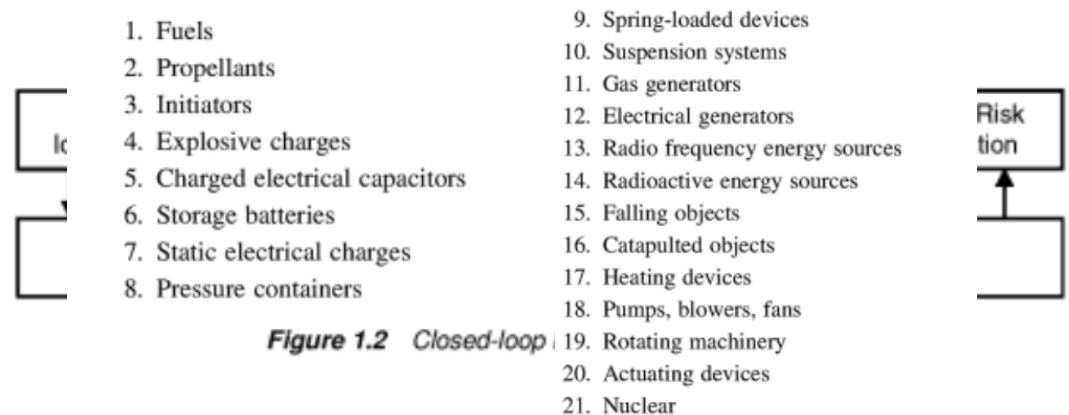


Figure 1.2 Closed-loop

# 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)

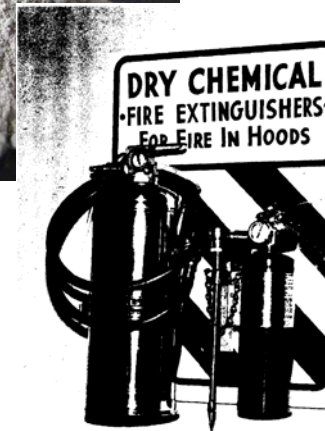
- Manage Combustibles/Housekeeping



# Plutonium (Moving Forward)

- Have the appropriate type and quantity of suppressant on hand

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



LALIZAS



# Plutonium (Moving Forward)

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Inspections

Walkdowns

Field Verifications

Get into facilities  
to

Ask questions  
to

Verify information  
and

Understand the conditions

# Plutonium (Recap)

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- **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?

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**Topic:** Fire Protection in Plutonium Facilities

**Presenter:** Rob Plonski

**Contact:** RobPlonski@YourFPE.com



  
[www.YourFPE.com](http://www.YourFPE.com)

# Extinguishing Pu Fires

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[VIDEO HERE](#)