BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE

SOUTHERN ANTI-PLUTONIUM CAMPAIGN

PLUTONIUM: THE LAST FIVE YEARS

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Executive Summary

On February 6, 1996 former Secretary of Energy Hazel O'Leary held her last media conference to announce her departments latest openness initiative. The era of openness following four decades of secrecy in the U.S. Nuclear Weapons Complex peaked on that day. The past five years has been marked by backlashes across the Department of Energy's (DOE) weapons complex against the concepts of right-to-know and open and honest government. The one notable exception is the admission by Secretary of Energy Bill Richardson that nuclear weapons workers were poisoned on the job, and Assistant Secretary David Michaels' national town-meetings involving thousands of current and former nuclear weapons workers.

> **Secrecy Was Wrong Then.**
>
> **"The problems have resulted from a 40 year culture cloaked in secrecy and imbued with a dedication to the production of nuclear weapons without a real senstitivity to protecting the environment."**
>
> **Admiral James Watkins, Secretary of Energy, October 5, 1989.**

This report focuses on DOE's plutonium management program, where DOE has earned an F for openness and honesty after five years of

- frequent and persistent usage of misleading and incorrect information in Environmental Impact Statements;
- a lack of updates from the out-dated 1993-1996 declassification of plutonium and highly enriched uranium;
- a growing propensity to quietly renege on major decisions that were made with great fanfare;
- A hostile attitude towards meaningful public involvement;
- An apathetic approach towards reducing the inherent dangers of plutonium stored in unsafe and highly unstable forms;
- Incompetence bordering on negligence in caring for more than 12,000 plutonium pits;
- Misleading statements about the intentions of the Ministry of Atomic Energy of the Russian Federation;
- Secretly developing new capabilities for plutonium pit production while touting dual-use plutonium processing facilities as "nonproliferation missions;"
- a refusal to acknowledge the health impacts of beryllium processing associated with plutonium work at the same time billions of dollars are allocated to compensate beryllium victims.

While DOE has continued to declassify information and more information is available than ever, this is not the true mark of openness. Openness and honesty is characterized by up-front revelations about the real hazards, uncertainties, and economics of new projects; and not by facades of unwarranted optimism and a flippant disregard for the public trust. When people are engaged in a process like Environmental Impact Statements that lead to a Record of Decision signed by top-level officials, they have an expectation that a small group of bureaucrats will discard the decision at the earliest convenience. Nowhere is this more true than in the plutonium program, where DOE has made numerous claims during the public debate that are contradicted by internal memos, obscure reports, and even public documents available on various Departmental Internet sites.

One fact that has become increasingly clear is that the plutonium hazard has more depth and breadth. Not only is plutonium useable in nuclear weapons at the scale of kilograms and acutely toxic at the scale of milligrams, it is also has the most complex chemistry in the Periodic Table of the Elements (Pages 1.3 to 1.6). DOE officials who have told the public countless times that alpha radiation can be blocked by a piece of paper have failed to inform people that alpha radiation from the decay of plutonium 239 causes, over the course of decades to centuries, damage to plutonium metal, any metal in contact or near contact with plutonium, and adverse chemical reactions with our most common elements, oxygen and hydrogen. All these things also make keeping track of plutonium much more difficult.

If the alpha particles from the decay of plutonium 239 can damage the densest metal on earth, the impacts of alpha radiation from plutonium ingested or inhaled n the human body is obviously detrimental. Plutonium is often said to be "harmless" if ingested as a metal, but this is an obvious fallacy since it turns out that plutonium metal has a microscopic layer of plutonium oxide present at all times. The chemical reactions with common materials that worry metallurgists and weapons designers are certainly a concern inside the human body. (Page 1.6).

Plutonium is most hazardous in an oxide powder form., with inhalation of only 20 milligrams enough to kill someone quickly (Page 1.6) and 30 to 60 micrograms easily enough to greatly raise the risk of cancer. Yet, DOE is planning to truck 3 metric tonnes of plutonium oxide from Rocky Flats to Savannah River Site this year in its politically motivated rush to close Rocky Flats as soon as possible.

Although the revelations about plutonium complexity has forced DOE to finally establish a long term plutonium storage standard, it is pursuing projects at odds with its own standards. The best example is DOE's zealous pursuit of a plutonium MOX fuel factory that utilizes surplus weapon-grade plutonium found in plutonium pits.

To make this fuel requires nitric acid based plutonium processing that has generated tremendous radioactive waste problems in the past, a process that greatly increases the likelihood of explosions, spills, and accidental criticality. Yet, the plutonium storage standard requires plutonium oxide to be heated to temperatures that make nitric acid processing even more dangerous. (Page 1.7). Instead of recognizing that plutonium fuel production from weapons plutonium is incompatible with its own storage standard, DOE seems intent on neglecting its commitment to safe storage in favor of its devotion to plutonium fuel.

In the past five years, DOE has reneged on nearly every one of its plutonium management decisions (see sidebar on Page iii) that did not involve spreading the liability at Rocky Flats around the country as quickly as possible or pursuing the dream of stuffing aging nuclear reactors one-third full of plutonium fuel. While underfunding the most fundamental mission—safe and secure storage—it has spent millions of dollars on unnecessary projects like gallium removal experiments and an irrelevant MOX fuel test in Canada.

DOE has not released updated plutonium inventory figures in five years and has even silently carved away bits and pieces of the declared surplus:

---In November 1999, DOE removed 3.8 (MT) of surplus plutonium found in unirradiated nuclear fuel in Idaho (Page 2.9) which forced the planning team for the plutonium immobilization plant at SRS to issue its third design; and another 0.6 to 0.8 MT of unirradiated nuclear fuel at Hanford was removed for "possible programmatic use."

---In 1998 an undisclosed number of surplus plutonium pits were recategorized as "national security assets;" (Page 3.3)

---In 1998 the nuclear weapons program at Los Alamos received "permission from the politicians" to divert some "nickel-sized" pieces of plutonium from its pit disassembly and conversion demonstration project for plutonium aging studies in support of nuclear weapons stockpile stewardship;
(Page 2-12).

DOE matched this failure to be up-front with its numbers with an aversion to being up-front about the hazards of its proposals. During the Surplus Plutonium Disposition Environmental Impact Statement process, DOE attempted to hide the fact that plutonium pit disassembly and conversion involved tritium and beryllium processing that would have meant a 10,000 fold increase in radioactive air pollutants at Pantex and will mean that SRS will become a certifiable beryllium site.

Broken Promises, Abandoned Decisions

The Department of Energy has proven adept at canceling major projects that formed the foundation of its plutonium program and were included in major Records of Decision by the Secretary of Energy:

In 1997 DOE canceled its effort to repackage 12,000 plutonium pits in "state-of-the-art" AT-400A shipping and storage containers at Pantex. After spending $50 million on research and development, the plug was pulled after a mere 20 plutonium pits were repackaged. (Page 3.14)

In December 1997 DOE abandoned its efforts to upgrade Building 12-66 at Pantex for surplus plutonium pit storage after completing the preconceptual design work. (Page 3.15)

In 1999 DOE abruptly canceled construction of a new plutonium storage and stabilization facility at Savannah River Site after spending $70 million on its design and nearly completing excavation work. Two years later, DOE still does not have a long-term storage plan for non-pit plutonium at SRS, but still plans to truck about 9 metric tonnes from Rocky Flats to SRS. (Page 2.).

In fiscal year 2000 DOE quietly stopped funding the plutonium pit reuse project at Pantex, a program designed to avoid costly and environmentally damaging plutonium pit fabrication. (Page 3-12).

In 1997 DOE ceased plutonium stabilization efforts at Los Alamos in favor of pursuing the ARIES project, which has turned out to be an essential pre-cursor to plutonium pit production.

In 1999 DOE began shipping plutonium residues called "sands, slags, and crucibles" from Rocky Flats to SRS, then abruptly quit and decided to send the material to WIPP.

Higher on the list was DOE's selection of a nitric-acid based plutonium conversion process for making Mixed Oxide (MOX) plutonium fuel in 1997. Unfortunately, DOE did not inform the public of its decision until late in 1999 and then grossly underestimated the impacts of the operations.

But the most egregious example of dishonesty was the public presentation of plutonium disposition facilities as nonproliferation missions while DOE officials, at the urging of the Pentagon and Congress, secretly crafted a parallel plan to produce new plutonium warheads. The possibility of SRS dismantling plutonium pits for a few years and then putting new ones together is very real. (Pages 3.15 to 3.19).

The list includes internal stonewalling, drastic funding cuts on fundamental programs, constant redesign and "rebaselining," and a plethora of contradictions:

- In spite of repeated requests, the National Laboratories have not provided Pantex with a list of plutonium pits called "National Security Assets" in nearly two years. The labs' inabilities to provide consistent storage criteria has contributed to the unease about plutonium pit conditions.
- (Page 3.3)

- After five years of inventory and the introduction of new technologies, DOE still cannot say whether or not it still has 2.8 metric tonnes of unaccounted-for plutonium; (Page 2.3)

- While the Office of Fissile Materials Disposition tells the country that it must accept the plutonium fuel option because Russia will not accept the U.S. burying its weapons-grade plutonium, the Office of Environmental Management keeps proposing to bury more plutonium residues containing weapon-grade plutonium in the Waste Isolation Pilot Plant in New Mexico
- (Page 2.).

- During five years of Environmental Impact Statements, DOE never informed the public that declassification of pits included declassifying the isotopic composition. One month after the January 2000 Record of Decision to build a PDCF at SRS was signed, the "blending" of plutonium oxides from two or more pit types was required to declassify the isotopic composition of the powder, adding yet another complication to an already confusing program.. (Page 3.8)

- DOE has spent two years "studying" options for long-term storage of plutonium at SRS, while hiding its planning process under the rubric of "predecisional."

- The plutonium pit program continues to languish from a lack of funding, as DOE refuses to honor its commitments to repackage the pits at a rate of 200 per month, insure that "dirty" pits are cleaned prior to storage, procure thousands of new containers for its "national security assets," decide on a facility storage plan, and design a shipping container. (Pages 3-12 to 3-13)

As a result of this investigation, BREDL is making the following recommendations to the new administration in the hopes that health and safety will take precedent over political expediency, that the fundamental issue of safe and secure storage receives the highest priority, and that no more huge sums of money are squandered:

1. There must be a renewed attitude towards increased openness and honesty in the U.S. nuclear weapons complex and a reversal of the current trend against openness.

2. DOE must publish its latest inventories of plutonium, uranium, and other special nuclear materials and disclose any information suggesting that diversion of materials has occurred. BREDL is making the following estimates based on DOE's figures in various reports, showing the sheer volume of plutonium "items," requiring individual handling at some point in time:

<table>
<tr><th colspan="4">Plutonium Inventory</th></tr>
<tr><th colspan="2">Plutonium Form</th><th># Items</th><th>Plutonium Content, MT</th></tr>
<tr><td rowspan="5">Non-Pit Plutonium</td><td>Solutions</td><td>43,000 Liters</td><td>0.5</td></tr>
<tr><td>Metals</td><td>6361</td><td>8.6</td></tr>
<tr><td>Oxides</td><td>12537</td><td>6.35</td></tr>
<tr><td>Residues</td><td>29530</td><td>6.35</td></tr>
<tr><td>Unirradiated Fuel</td><td>52,000</td><td>4.4</td></tr>
<tr><td colspan="2">Plutonium Pits</td><td>20,000</td><td>66.1</td></tr>
<tr><td colspan="2">Irradiated Fuel</td><td></td><td>7.5</td></tr>
<tr><td colspan="2">Total</td><td>120,528</td><td>99.8 to 100.0</td></tr>
</table>

3. Insure that DOE lives up to its promises and commitments made in Environmental Impact Statements and in implementation Plans to the Defense Nuclear Facilities Safety Board.

4. Make safe and secure storage of plutonium the number one priority in the weapons complex.

5. Cease all efforts to pursue full-scale plutonium pit production and a plutonium fuel economy and focus on reducing the plutonium hazard.

6. The inherent chemical instability of plutonium should be an added incentive to make drastic cuts in the nuclear weapons arsenal.

Part I: The Trouble With Plutonium

A Review of Plutonium Destructiveness, Complexity, and Hazards [1]

Plutonium will be with us for a long time, and not only because it has a radioactive half-life of 24,000 years and therefore is dangerous for more than 200,000 years. Plutonium will be with us because nuclear weapon states are deeply devoted to having it as a military presence, the global nuclear power establishment is deeply devoted to pushing it as the fuel of the future, and the personal and political opinions of scientists often carry more weight than their scientific opinions.

A passage from the most recent issue of *Los Alamos Science, No. 26*–which is must reading for plutonium foes and friends alike–illustrates this reality:

> *"Regardless of popular or political opinions about the uses of plutonium, plutonium processing will continue globally at least for many decades. In the United States, plutonium plays a central role in national defense; it is routinely formed into samples for experiments, cast or machined into nuclear weapon pits, and extracted from retired nuclear weapons or weapon components and prepared for disposal. All of these activities require that plutonium be chemically or mechanically processed."*[2]

This emphasis on the military use of plutonium suggests that without the military applications, support for "peaceful uses" of plutonium 239 would be meager. Plutonium may be a nuclear weapons physicists' dream (see sidebar), but the dreams of physicists do not always come true, as is evident in the case of the now defunct Superconducting Super Collider project of the 1980's.

So while the pro-plutonium inertia is powerful, it is not omnipotent and the future of this element and other special nuclear weapons materials is not set in stone. As the debate continues to unfurl, it is important for people to know that this most secret of elements is the most complex metal in the periodic table; and its presence in deployed nuclear weapons threatens life as we know it.

Nightmare or Dream?

"Plutonium is a physicist's dream but an engineer's nightmare. With little provocation, the metal changes its density by as much as 25 percent. It can be brittle as glass or as malleable as aluminum; it expands when it solidifies, much like water freezing to ice...it is highly reactive in air...plutonium damages materials on contact and is therefore difficult to handle, store, or transport. Only physicists would ever dream of making and using such a material. And they did make it–in order to take advantage of the extraordinary nuclear properties of plutonium-239." *Plutonium, An Element at Odds with Itself.* Los Alamos Science. 2000. Number 26.

Plutonium in Nuclear Explosives

Plutonium-239 is a fissile material well-known for its use as the primary trigger in most nuclear explosives (Figure 1-1). All grades of plutonium (see Table 2-1) are considered useable in nuclear explosives, but weapon-grade plutonium--which contains more than 92% plutonium-239--is preferred for nuclear weapon arsenals because lower amounts of plutonium-239 found in fuel and reactor grade pose a much higher risk of "pre-initiation" of the trigger due to corresponding higher amounts of plutonium-240. Use of lower grades also makes fabrication of the plutonium trigger, or pit, more difficult.[3] Because of its use in weapons of mass destruction, plutonium accounting is conducted to the level of grams, and large security forces are necessary to guard it.

However, the use of fuel or reactor grade plutonium is considered an easier path for a nonweapons state or a terrorist group because: easiest way to make a nuclear weapon is with reactor-grade plutonium because:

- there is much more of it in the world, approximately 1300 metric tonnes in irradiated nuclear fuel, and another xx MT separated and awaiting use as reactor fuel.
- it does not require the use of a "neutron generator." As the Department of Defense puts it, " a nuclear device used for terrorism need not be constructed to survive a complex stockpile-to-target sequence, need not have a predictable and reliable yield, and need not be efficient in its use of nuclear material."[4]

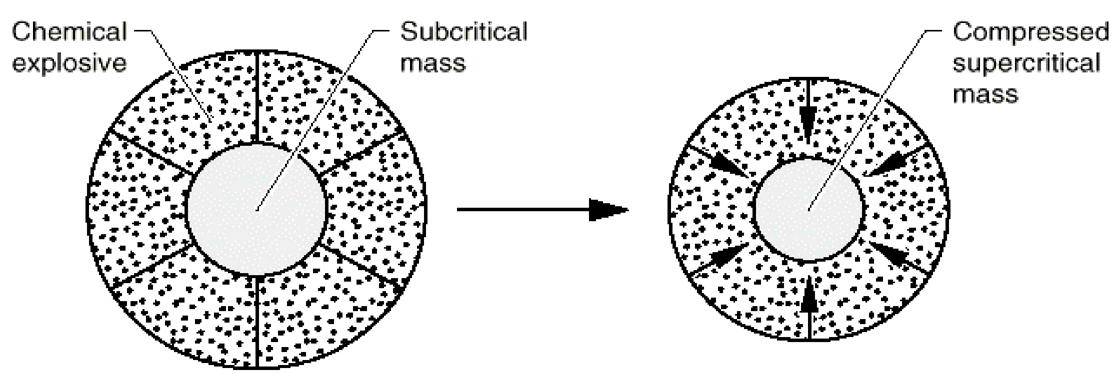

Figure 1-1. A simplified illustration of how a precise detonation of chemical high explosives surrounding a subcritical mass of fissile materials generates enough force to initiate, or trigger, the nuclear detonation. Source: Los Alamos Science. Number 23. 1993. Page 55.

Plutonium Chemical Complexity

If anything contributes to plutonium's demise as a military tool it will be its inherent chemical instability. The future of the plutonium triggers in the U.S. nuclear weapons stockpile is the focus of intense debate both internally and externally to the weapons labs and in the Pentagon. In particular, the lack of understanding of how plutonium ages is driving calls for renewed large-scale pit production. Lawrence Livermore National Laboratory spins it this way, "predicting kinetics is crucial to avoiding surprise requirements for large-scale refurbishment and remanufacture of weapons components."[5]

Plutonium is cited by the nuclear weapons labs as the most complex metal in the periodic table and continues to baffle people who best understand it (see sidebar). U.S. and Russian weapons scientists do not even agree on the "phase diagram" for the easily machinable delta-phase plutonium that dominates nuclear weapons stockpiles.[6] Its traits are commonly described as unstable, unpredictable, anomalous, and dramatically variable in the open literature. The litany of difficulties includes:

Baffled Scientists

"**We conclude that the present understanding of plutonium chemistry is inadequate and that the new evidence presents an immediate challenge to the scientific community**."
Hascke, Allen, and Morales. *Surface and Corrosion Chemistry of Plutonium.*

"**The bad news is that plutonium is very complicated...we actually don't know how aged plutonium**."
Dr. Bruce Tarter, Director of Lawrence Livermore National Laboratory.

Delta-phase plutonium-gallium alloy is the "most useful and familiar phase [but] the least understood theoretically." Sig Hecker, Los Alamos National Laboratory.

"**Seaborg had the choice of picking the symbol Pl or Pu for plutonium. He remarked that it is really kind of a stinky element (complicated chemistry and unusual metallurgical properties) so it became Pu.**"
R.H. Condit. *Plutonium. An Introduction.*

- an inherent instability marked by adverse reactivity as a metal or an oxide powder with common items like air, water, and oils, which also "makes it difficult to keep track of plutonium inventories."[7]
- corrosion from hydrides and oxides from the outside-in and from radioactive decay from the inside-out;
- runaway corrosion reactions;
- an ability to cling "tenaciously" to anything and everything;[8] resulting in buildups of plutonium in ductwork, piping, and ventilation systems;
- ultra-sensitivity to temperature and pressure changes, with marked increases in density with phase changes (Figure 1-3);
- an "anomalously low melting point;"
- **pyrophoricity:** spontaneous ignition at certain temperatures and certain particle sizes.

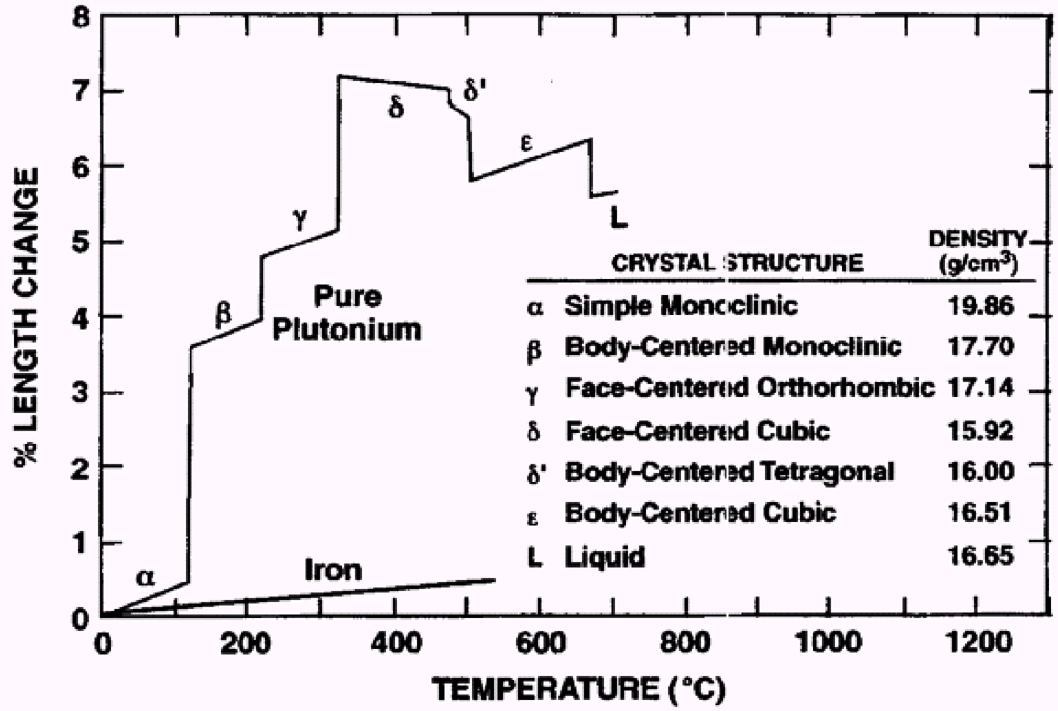

Figure 1. Length change, crystal structures, and densities in pure plutonium during heating.

Figure 1-2. This diagram is commonly used to illustrate plutonium complexity, showing the contrasts between the dramatic and abrupt six phase changes of plutonium as it is heated compared to the stability of iron. Some of the key traits of the different phrases include:

- Alpha-phrase plutonium is brittle and difficult to machine, like cast iron.
- Small amounts of aluminum alloyed with delta-phase plutonium stabilize the plutonium and produces a metal as machinable as aluminum. However, because aluminum emits neutrons upon absorbing alpha particles from the decay of plutonium, it raises the risk of pre-initiation, or early criticality, of the plutonium trigger.
- Gallium alloyed with delta-phase plutonium retains the benefit of a product nearly machinable as aluminum and far less prone to plutonium oxidation without raising the risk of pre-initiation, and therefore the plutonium-gallium alloy is the most common in plutonium pits.

To make plutonium fuel, DOE intends to destabilize plutonium by removing gallium during purification.

Plutonium Hazards

The combination of radioactivity and chemical instability makes plutonium in the workplace an inherently unsafe enterprise even after it is produced and separated. Add to this the need for precise accounting to the gram level and large protective forces to guard vaults and other storage areas, and the costs of dealing with plutonium become exorbitant

> "**Many opportunities exist for mistakes in working with plutonium chemistry...The penalties for mistakes include spills of radioactive materials and possibly criticality experiments**."
> R.H. Condit. *Introduction to Plutonium*.

Primary among the numerous aspects of the plutonium radiation hazard is the fact that it takes 24,400 years for it to lose one half of its radioactivity, meaning that it will remain dangerous for hundreds of thousands of years and react adversely when exposed to common environments.

Alpha Radiation and Decay

Plutonium-239 emits high levels of alpha radiation (Figure 1-3). Although alpha radiation can be stopped with paper, it causes damage in many ways and from several phenomenon.

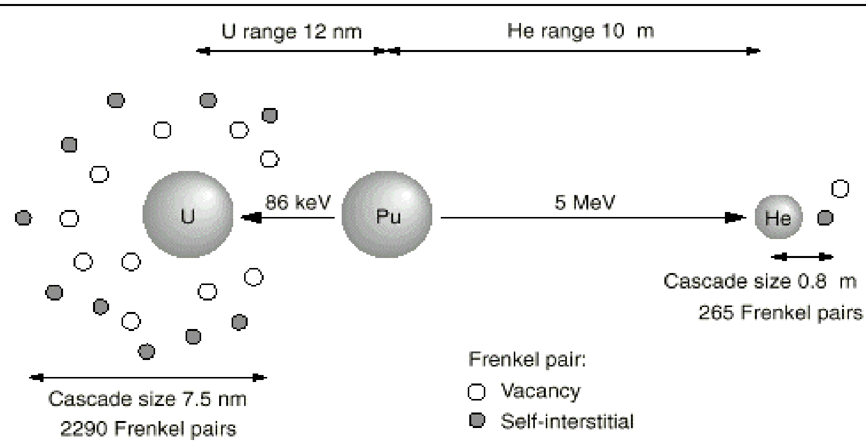

Figure 1-3. The first part of the plutonium-239 decay chain. Plutonium decays to Uranium 238 by emitting an alpha particle, in this case a helium nucleus. The energy from this process drives several reactions that are poorly understood.
Source: Los Alamos Science. Number 26. 2000.

1. **Damage to the plutonium over time**. The recoil energy from the decay generates 85 kilo-electron-volts of kinetic energy in the uranium nucleus, of which 60 keV remains when the nucleus collides within

the matrix and displaces plutonium atoms in the metal.[9] Over the course of decades, this action can damage plutonium enough to keep weapons designers leery of the "reliability" of the plutonium triggers.

The helium nucleus has far more energy when released, 5 million-electron-volts, but this is said to lose all but 0.1 percent of its energy through collisions with electrons before capturing a few electrons and "settling in" as a helium atom[10]. Over the course of decades, helium atoms accumulate to the point of creating bubbles, another grave concern of weapons designers. Helium buildup also poses a health and safety risk. For example, in 1963 a plutonium pit tube broke during a weapon disassembly process at Pantex and contaminated workers and the facility with plutonium contaminated helium gas.

2. **Damage to other metals over time.** Plutonium decay basically damages everything in its path, and this impact is most measurable on elements that experience "void swelling" from radiation, meaning they swell in size over time.[11] The effects of this over the course of decades is poorly understood because plutonium has never been allowed to age for decades, but some implications are obvious:

- Beryllium, which is used as a neutron tamper within pits and as cladding on many plutonium pits (see Part III) serving to protect the plutonium from oxidizing, experiences "gas-driven" swelling;.
- Aluminum, which is used in cladding on some pits, suffers from void swelling.
- Iron, Chromium, and Nickel, the key ingredients in stainless steel used for plutonium storage cans, experiences void swelling;
- Zirconium, used to clad nuclear fuel, experiences void swelling.

3. **Damage to live tissues**. If the uranium nuclei from decay damages metal as dense as plutonium, the impacts on living tissue are quite obvious. Plutonium is said to be "harmless" if ingested as a metal, but this is an obvious fallacy since even plutonium metal has a layer of plutonium oxide present at all times,[12] oxides are always present to some degree on metals, and the chemical reactions with common materials that worry metallurgists and weapons designers are certainly a concern inside the human body.

Plutonium is most hazardous in a powder form. Much debate has occurred over how much plutonium oxide can cause lung cancer within a few decades, with estimates ranging from a few micrograms to 30-60 micrograms to 2 milligrams. There seems to be little debate over how much will kill a person:

- Ingestion of 500 milligrams, or one half of a gram, is considered the acute lethal dose;
- Inhalation of 20 milligrams is considered the acute lethal dose;[13]

A good scale for reference is a typical Sweet N' Low packet which contains one million micrograms of sugar substitute.

4. Radiolysis of common materials. Alpha particles react with materials such as air and water to cause "radiolysis" of common materials (Figure 1-4). Plutonium metal oxidizes readily in air and plutonium oxide generates gases that can rupture storage containers. Plutonium is most hazardous in a powder form.

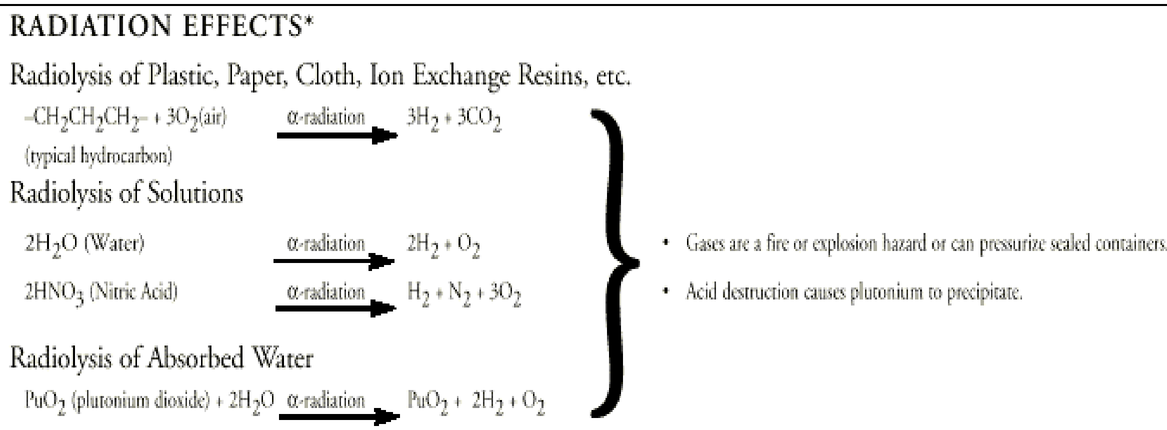

Figure 1-4. Simplified illustration showing various reactions brought about by alpha decay.
Source: Los Alamos Science. Number 26.

The literature is filled with reports about ruptured containers and massive oxidation of entire metal pieces. For example, in 1983 Los Alamos reported the formation of a black powdered suboxide in "casting skulls" left over from plutonium pit fabrication, and when containers of skulls were opened, the plutonium suboxide would ignite "almost explosively."[14]

To avoid these undesirable reactions, DOE finally established a long-term storage standard for plutonium in 1994, but has had trouble meeting that standard (see Part II, Section B.) Called the 3013 standard, it requires that plutonium metals and oxides be stored in two sealed metal containers free of organic materials. Reaching this standard requires heating of oxides to temperatures greater than 900 degrees Celsius. A few near-term implications of this chemical fact include:

1. Nitric acid processing, which DOE plans to use to purify plutonium oxide as the first step towards making plutonium MOX, greatly increases the likelihood of explosions, spills, and criticality events. The plutonium pit disassembly and conversion facility is planned as the main source of plutonium oxide for a plutonium fuel (MOX) factory. Early plans for the PDCF require the plutonium oxide product to meet the long term plutonium storage (3013) standard.[15]

2. The dangers of nitric acid plutonium processing are aggravated if the plutonium oxide was produced or treated at temperatures greater than 600 degrees Celsius. Oxides heated to temperatures between 600 and 1000 C "require somewhat more stringent procedures" when dissolving in acids, and plutonium oxide powder heated to temperatures over 1000 Celsius "require extreme measures."[16] **Since the long-term storage standard requires plutonium to be heated at temperatures well above 600 degrees C,[17] it is incompatible with the needs of plutonium fuel production.**

Aging Plutonium and Americium-241

Plutonium-241, which is present in all grades of plutonium, decays into the more radioactive and dangerous americium-241, an intense gamma ray emitter that is 100 times more toxic than plutonium 239. Weapons plutonium was routinely purified to eliminate americium, which of course produced stockpiles of americium. If plutonium decay is allowed to run its course,
radiation levels in U.S. plutonium will peak in the next 38 to 60 years (Figure 1-4).

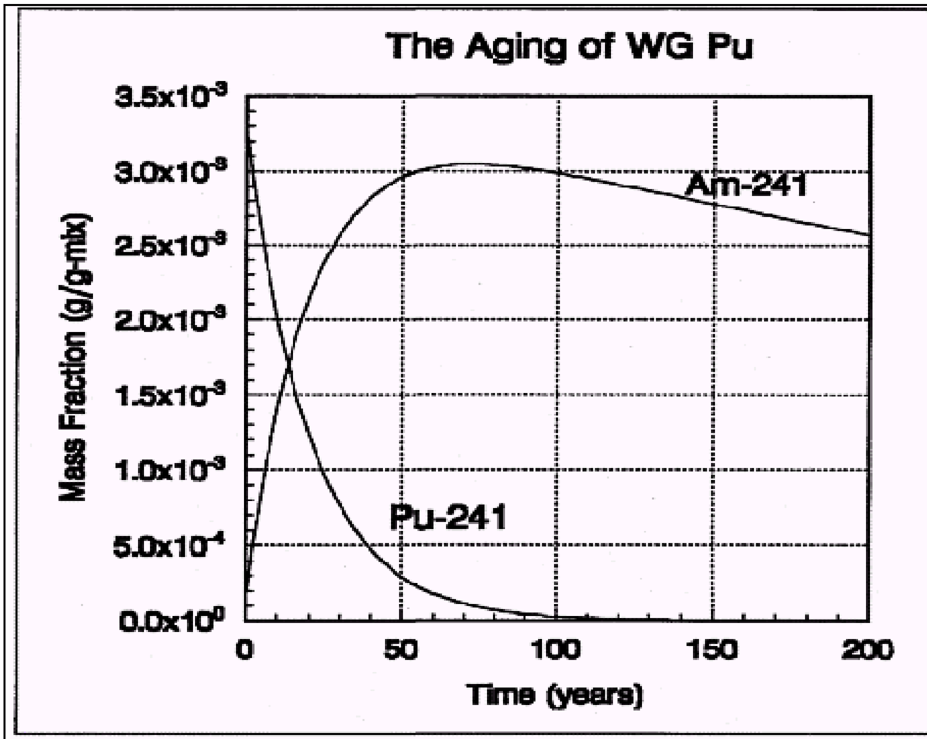

Figure 1-4. As plutonium-241 decays to Americium-241, weapon grade plutonium becomes more hazardous and radioactive. Americium levels peak after 70 years. Source: Peterson, 1993. RFP-4910.

Endnotes

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1. For in-depth overviews of plutonium and other special nuclear materials, see:

International Physicians for the Prevention of Nuclear War. 1992. *Plutonium, Deadly Gold of the Nuclear Age.* (Second Printing with Corrections in 1995).

Nuclear Wastelands.

2. Avens, Larry R. and P. Gary Eller. 2000. *A Vision for Environmentally Conscious Plutonium Processing.* Los Alamos National Laboratory. In*: Challenges in Plutonium Science.* Los Alamos Science. Number 26. 2000. Page 436.

3. *Minutes of the Plutonium Information Meeting*. Rocky Flats Plant. January 29-30, 1959. Sanitized version from DOE Archives.

Dow's opinion is that the increase in Pu-240 and Pu-241 inherently increases the gamma hazard. The short half-life of the Pu-241 (13 years) gives rise to an early radiation hazard due to the daughter products. The Pu-241 decays to Am-241 (beta 100%) and U-237 (alpha .004%). For periods of a

This excerpt from the "Minutes of the Plutonium Information Meeting" shows that Rocky Flats contractor and plutonium pit fabricator Dow Chemical voiced concerns to the introduction of fuel and reactor grade plutonium to the nuclear weapons stockpile. The purpose of the meeting was to discuss the impacts of Lawrence Livermore National Laboratory's weapon designs using reactor fuel.

4. DoD Militarily Critical Technologies list. Nuclear Weapons Technology. Section 5.

5. Lawrence Livermore National Laboratory. *Stockpile Stewardship Program*. UCRL-LR-129261.

6. Hecker, Sigfried. 2000. Los Alamos Science. Number 26, and *Plutonium Aging: From Mystery to Enigma*. LA-UR-99-5821. 1999.

7.Condit, R.H. 1993. *Plutonium: An Introduction*. Lawrence Livermore National Laboratory. UCRL-JC-115357. Prepared for submittal to the Plutonium Primer Workshop. DOE Office of Arms Control and Proliferation in Washington, D.C. on September 29, 1993.

8. U.S. DOE. *Plutonium, the First Fifty Years*; 1996; and *Declassification of Plutonium Inventory at Rocky Flats*, Colorado, 1994.

9.*Radiation Effects in Plutonium*. Los Alamos Science. Number 26.

10.Ibid.

11.Ibid.

12. Haschke, John. 2000. *The Surface Corrosion of Plutonium*. Los Alamos Science. No. 26.

13. Condit, R.H. 1993. *Plutonium: An Introduction*; and *Plutonium Storage* by John M. Haschke and Joseph C. Martz.

14.LA-3542. *Plutonium Processing at LANL*. 1983.

15.Westinghouse Savannah River Company. 2000. *Facility Design Description for Pit Disassembly and Conversion Facility.* . February 24, 2000. Page 55.

16.Plutonium Processing at LANL . 1983.

17. DOE Standard 3013.

Part II: The U.S. Plutonium Stockpile
An Update on the Numbers

In 1996 the Department of Energy (DOE) released “Plutonium, The First 50 Years,” in which the U.S. declared it had acquired 111.4 metric tonnes (MT) from four sources:

- 103.4 MT from government-owned plutonium production reactors (36.1 MT at Savannah River Site (SRS) and 67.3 MT at Hanford);
- 0.6 MT from government-owned nonproduction reactions;
- 1.7 MT from commercial U.S. nuclear reactors that was primarily received from West Valley, N.Y. reprocessing plant;
- 5.7 MT from foreign countries.

The active military plutonium inventory held by DOE and the Department of Defense (DoD) was declared to be 99.6 metric tonnes (MT), broken down into 3 categories.[1] (Table 1-1).

Table 2-1. Declared Inventory, 1996.		
Grade	% Plutonium-240	Total Pu, Metric Tonnes
Weapons Grade	< 7%	85.1
Fuel Grade	7-19%	13.2
Reactor Grade	>19%	1.3
Total Plutonium		99.6 MT

This 99.6MT can be further broken down into three major categories: the plutonium in nuclear weapons triggers called plutonium pits, within irradiated nuclear fuel, or in non-pit form..

Table 2-2. Plutonium Inventory.				
Category	Weapon Grade	Fuel Grade	Reactor Grade	Total
Pits	66.1	0	0	66.1
Irradiated Fuel	0.6	6.6	0.3	7.5
Non-pit	18.4	7.6	0	26.0
Total	85.1	14.5	0.3	99.6
Nonpit plutonium breakdown is based on these three assumptions (1) Assumes all plutonium in pits are weapon-grade, since U.S. is not known to have developed plutonium weapons from non-weapon grade plutonium (although it did test such weapons). (2) Assumes that there is no non-surplus plutonium in irradiated fuel.				

(3) DOE Plutonium vulnerability report cited 26.0 MT of non-pit Pu in DOE complex.

Noting that due to "rounding" its figures did not always match up, DOE claimed that 12.0 MT of plutonium has been "lost" or sent abroad, so the active inventory is the acquired plutonium minus the following (note that DOE admitted that due to rounding its figures did not always add up):

- 3.4 MT "expended" in wartime and nuclear weapons testing;
- 2.8 MT of plutonium DOE cannot account for called "inventory differences;"[2]
- 3.4 MT of plutonium in waste forms described as "normal operating losses."
- 1.2 MT of plutonium lost during nuclear reactor operations described as "fission" and "transmutation";
- 0.4 MT of plutonium that decayed to Americium 241 and uranium 237.
- 0.1 MT of plutonium now in the hands of the U.S. civilian industry;
- 0.7 MT of plutonium sent to foreign countries under "agreements for cooperation," i.e. the Atoms-For-Peace program;

Changes Since 1996

Last year DOE submitted a report to Congress called the *Integrated Nuclear Materials Management Plan*. The active inventory declared was the same as that of 1996. This is unlikely to be the case for the following reasons:

1. Contractors operating DOE plutonium sites are required to conduct inventories on all Special Nuclear Materials (SNM) and report updated inventory differences. For example, at Savannah River Site (SRS), the Materials Controls and Accounting (MC&A) department is directed to "reconcile SRS nuclear material records with NMMSS (U.S. Nuclear Materials Management Safeguard System) semiannually" and "provide to OSS (Office of Security and Safeguards) semi-annual reports on statistical analyses of inventory differences."[3] Therefore the Department has updated figures on material-unaccounted-for (MUF), now known as "inventory differences."
The question that remains is: **Does DOE still have 2.8 MT of unaccounted-for plutonium?**

2. In response to an investigation by the Institute for Energy and Environmental Research (IEER), DOE acknowledged there is more buried plutonium waste at Idaho, SRS, RFETS, and Hanford.[4] Therefore, the amount of plutonium in waste is also likely to be higher, which would mean lower inventory differences.

3. DOE has changed how it classifies waste vs. non-waste plutonium,[5] and now appears intent on trying to send as much plutonium as waste to the Waste Isolation Pilot Plant (WIPP) in New Mexico as possible.

4. Plutonium has done nothing but decay the last five years, so more has been lost.

5. Stabilization efforts of non-pit plutonium should have led to better estimates, especially considering the advances in technology for materials accounting.

6. DOE opened a new plutonium storage site, the Waste Isolation Pilot Plant, in New Mexico; where it intends to bury more than ten metric tonnes of plutonium as waste.

Non-Pit Plutonium

The amount of non-pit plutonium is complicated by several factors:

- the inherent difficulty of measuring and accounting for plutonium;
- the fact that many materials with 10-30% plutonium content are poorly characterized;
- the changes in U.S. policy regarding waste vs. recoverable materials;
- whether plutonium in pits was a part of the declassified inventory at Rocky Flats and SRS
- The ownership of the plutonium within the DOE bureaucracy and the lack of final decisions regarding the fate of numerous materials.

When Production Stopped

Prior to 1990, when nuclear weapons production was in high gear, "the vast majority of fissile material scrap and materials from retired weapons was recycled. It was less costly to recover fissile materials from high assay scrap and retired weapons than to produce new material. As a result, very little scrap containing fissile material was considered surplus. Consequently, these materials were designated, handled, and packaged for short-term storage."

Confusion about Nuclear Materials

The flow and storage of SNM [Special Nuclear Material], including tritium, throughout the DOE complex [prior to 1990] was fairly complicated and could be somewhat confusing to the unitiated observer. In fact, it could be somewhat confusing to an experienced observer as well."
Albert Abey, Lawrence Livermore National Laboratory. UCRL-ID-111061. 1992.

In 1989, when the U.S. stopped producing special nuclear materials and numerous facilities were shut down, there was no long-term standard for storing plutonium. In fact, not much thought was even given to storage until it became a problem:

> *"the halt in weapons production that began in 1989 froze the manufacturing pipeline, leaving it in a state that posed significant risks. High quantities of fissile materials (approximately 13 tons of plutonium metals and oxides, 400,000 liters of plutonium solutions, 130 tons of plutonium residues, HEU, and special isotopes) needed attention."*[6]

By 1994 DOE had finally developed a standard for long-term storage–up to 50 years–of non-pit plutonium metals and oxides, commonly called the 3013 Standard. However, between 1989 and 1994 DOE made insignificant progress resolving the actual problem.

Change began in April 1994 when the Defense Nuclear Facilities Safety Board (DNFSB) issued its first Technical Report. *Plutonium Storage Safety at Major Department of Energy Facilities* addressed all unencapsulated, separated plutonium., leaving out plutonium in pits, unirradiated nuclear fuel, and sealed sources. The report chastised the DOE for not clearly recognizing many of the hazards associated with plutonium storage, such as potential fires, explosions, and pressurization of containers.[7] (Three years later a major chemical explosion forced Hanford to shut down its Plutonium Finishing Plant.)

A month later the Board issued Recommendation 94-1 for this plutonium and other special nuclear materials. At the top of the list of nine recommendations encompassed within 94-1 was the recommendation to:

> *"convert within two to three years the materials...to forms or conditions suitable for safe interim storage. The plan should include a provision that, within a reasonable period of time (such as eight years), all storage of plutonium metal and oxide should be in conformance with the draft DOE Standard on storage of plutonium now being made final."*[8]

Also in 1994 the DOE conducted a detailed plutonium vulnerability investigation and published a landmark document of the results, including the detailing of plutonium holdings down to the gram level at numerous "small holding" sites documenting approximately 26.0 MT of non-pit separated plutonium.. In February 1995, a few months after publishing the vulnerability report, the Department sent its first plan with new plutonium estimates (Table 1-3) for implementing Recommendation 94-1 to the Defense Board, and acknowledged the urgency of the issue:

> *"The Department acknowledges and shares the Board's concerns and has developed this integrated program plan to address these urgent problems."*[9]

Table 2-3: Differences in separated, unencapsulated Plutonium Inventory between DOE's Implementation Plan for Recommendation 94-1 and DOE's Plutonium Vulnerability Report

Plutonium Form	MT of Pu 94-1 Implementation	MT of Pu Vulnerability Report
Oxide	6.21	3.3 (1)
Metal	8.95	13.0 (1)
Scrap/Residues	6.34 (2)	8.7
Solutions	0.49 (2)	0.7
Sealed Sources	not reported	0.05
Other Forms	not reported (3)	0.24
Total	21.7	26.0

(1) These figures included plutonium in unirradiated nuclear fuel.

(2) The actual amount of plutonium by form at SRS was classified in the first 94-1 implementation plan, although DOE reported 2.1 MT at SRS in 1994. Since then DOE has reported 0.490 MT in metals, and DNFSB reported approximately 0.8 MT in oxides and 0.4 MT of in residues at SRS in January, 2001. The estimate for Pu in solutions remains classified, the number in this table is an estimate based on the various numbers reported for SRS and the complex.
(3) Other forms may be encompassed within 94.1, but are not reported.

Not included in DOE's 94-1 implementation plan were 4.4 to 4.6 MT of plutonium in unirradiated fuel:

- 0.6 MT of plutonium in unused FFTF mixed oxxide fuel clad in 17,000 MOX fuel pins at Hanford;
- 0.2 MT to 0.4 MT of plutonium in unclad FFTF fuel pellets at Hanford;
- 0.3 MT of unused ZPPR fuel in 21,000 pins of mixed oxide fuel in Idaho (Figure 2-2)
- 3.5 MT of unused ZPPR plates within 29,000 plates of metal alloy fuel (Figure 2-3);

This provides more evidence that the 26.0 MT in the vulnerability report at sites other than Pantex was non-pit plutonium and did not include plutonium in pits, meaning that the original inventory at Rocky Flats was closer to 16.0 MT.

Implementation of DOE's nuclear materials stabilization plan has been hindered by several factors, many of them political:

- The political decision to "accelerate closure"at Rocky Flats, with an artificial deadline for closing all plutonium facilities by 2006;
- The political decision to pursue disposition of surplus plutonium through the "dual-strategy" of both plutonium fuel use and immobilization;
- The lack of commitment to safe and secure storage within the Department of Energy;
- The issue of who "owns" this plutonium, as it is managed by four DOE departments Offices of Nuclear Energy, Defense Programs, Environmental Management, and Fissile Materials Disposition.
- DOE's hopelessly fragmented approach to implementing the National Environmental Policy Act (NEPA), with the total plutonium program being addressed in several environmental impact statements.
- The 3013 standard has changed three times (3013-96, 30-13-99, and 3013-00).
- The nature of the materials, especially since the amount of plutonium contained in the complex was minor compared to the total quantities of materials that contained plutonium. (Figure 1-x_) .
- In 1999 DOE stopped construction of a cornerstone of its implementation plan, the Actinide Packaging and Stabilization Facility (APSF), leaving a gaping hole in the ground at Savannah River Site where excavation work was almost complete.

The fate of most of these materials remains unclear. One option is to dispose more plutonium as a waste at the Waste Isolation Pilot Plant (WIPP) in New Mexico. A more recent scheme proposed by the National Laboratories is to truck hundreds of tonnes of residues to SRS and separate and purify the

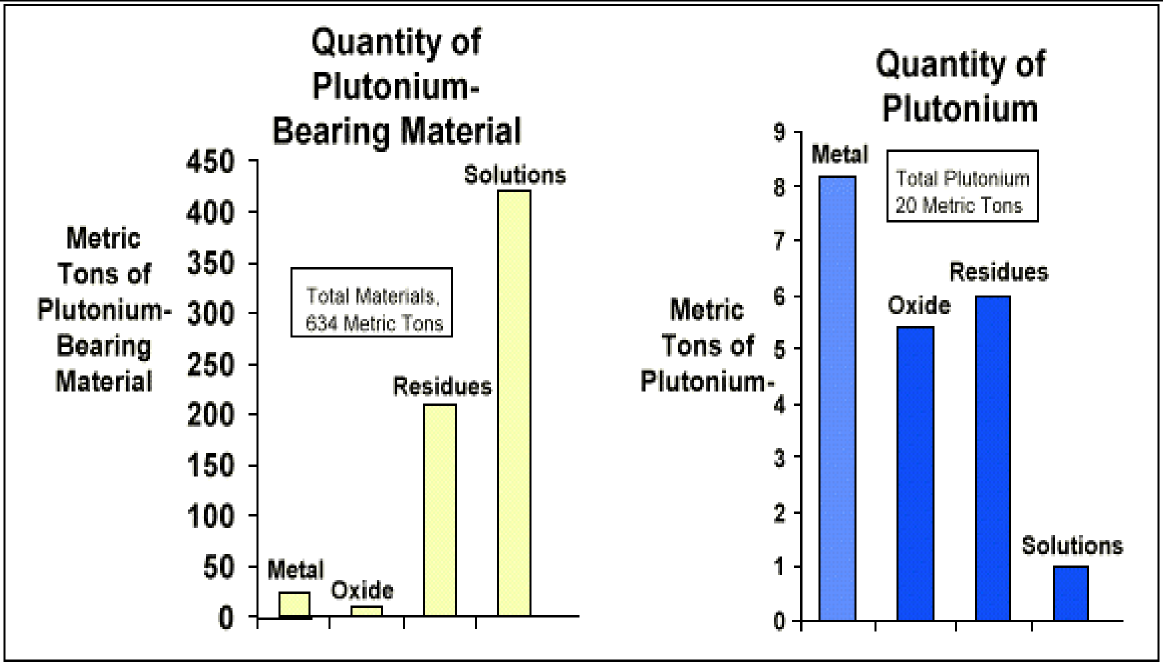


Figure 2-1. This graphic illustrates the quantity of materials compared to the plutonium in those materials. Much of the non-pit plutonium is not weapons-usable, yet the necessity to stabilize these materials from a health and safety standpoint results in weapons-usable plutonium. Source: DOE/ID-10631, Plutonium Focus Area. 1995.

plutonium. in the SRS canyons. The goal would be to increase–by 6-7 tonnes–:the amount of weapons grade plutonium and improve our negotiating stance with Russia."[10]

Because of the variations in DOE reporting, the actual inventory remains murky. Following are BREDL's estimates for the total number of items containing plutonium, and the plutonium content within those items.

Plutonium in Solutions

In the plutonium vulnerability report, DOE estimated a total of 700 kilograms (0.7 MT) of plutonium contained in various concentrations within 400,000 liters of solutions with high risks of criticality, explosions, and leaks:

- 143 kilograms at Rocky Flats
- 360 kilograms at Hanford
- a classified amount--estimated at approximately 200 kilograms--at Savannah River Site;

DOE's contractors have stabilized 90% of the plutonium solutions in terms of total volume, *but only about 30 % of the solutions in terms of plutonium content*:

- 43 kilograms of plutonium remains at Rocky Flats in 2,000 liters of solution in piping in 6 facilities;
- An estimated 110 kilograms of plutonium remains in H-Canyon at SRS in 34,000 liters of solution;*
- 341 kilograms of plutonium remains at Hanford's Plutonium Finishing Plant in 4,270 liters of solution
- A total of 494 kilograms, or approximately 0.5 MT, of plutonium in 40,270 liters of solutions.

Plutonium Metal

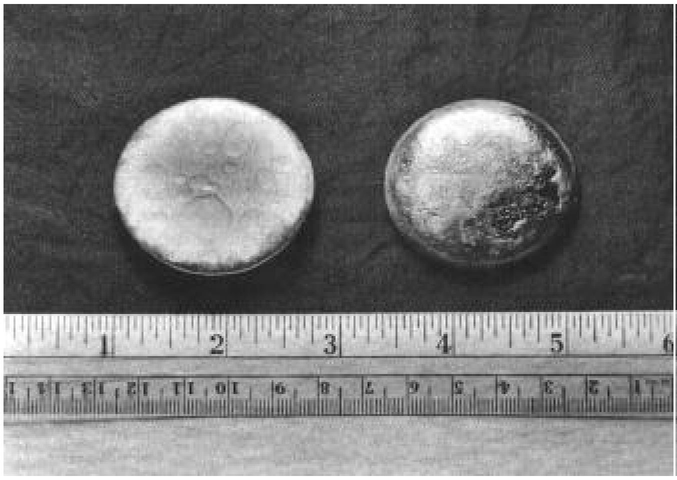


Figure 2-2. Plutonium Ingots.

As of June 2000, DOE reported 8,951.3 kilograms (8.951 MT) of plutonium metal contained in 6,361 items at 9 different sites:

- 6600 kilograms (6.6 MT) in 3403 containers at Rocky Flats;
- 700 kilograms (0.7 MT) in 475 containers in Hanford's Plutonium Finishing Plant
- 1133 kilograms (1.133 MT) in 2060 containers at Los Alamos
- 490 kilograms (0.49 MT) in 230 containers at SRS
- 0.45 kilograms (0.00045 MT) in 210 containers at Argonne East National Laboratory in Chicago;
- 20 kilograms (0.020 MT) in 50 containers at LLNL.
- 0.855 kilograms (0.00085 MT) in 20 containers at the Mound Plant in Ohio
- 0.3013 KG (0.0003 MT) in 30 containers at Oak Ridge;
- 6.7 kg (0.0067 MT) in 5 containers at Sandia National Laboratory. .

About 7.6 MT of this material is considered surplus, based on 28.9 MT of metals declared surplus minus the 21.3 MT of surplus plutonium in pits at Pantex.

1.0 MT of this material is categorized as fuel-grade plutonium. In all likelihood this includes the the 275 plutonium-aluminum alloy items at Hanford.

Table 2.4. Plutonium in Metals

Site	Pu Content in Metals, KG	# of Pu Metal Items
Rocky Flats	6600.00	3403
Hanford	700.00	339
Los Alamos	1133.00	2060
SRS	490.00	203
Argonne-East	0.45	210
Livermore	20.00	91
Mound	0.86	20
Oak Ridge	0.30	30
Sandia	6.70	5
Total	8591	6361

Plutonium Oxide

Figure 2-3. A can of plutonium oxide powder at Rocky Flats.

DOE has approximately 12,540 items of plutonium oxides with greater than 50% plutonium content, for a total of 6.35 MT of plutonium. Virtually none of this plutonium meets the long-term 3013 storage standard:

- 3,200 kilograms (3.2 MT) of plutonium within 3,296 items content at Rocky Flats;
- 1,500 kilograms (1.5 MT) of plutonium in 2,800 Pu oxide items and 2,300 plutonium-uranium oxide items at Hanford
- 800 kilograms (0.8 MT) of plutonium in 800 containers of Pu oxide at SRS;
- 721 kilograms (0.721 MT) of plutonium in more than 2,000 Pu oxide containers at Los Alamos;
- 102 kilograms (0.102 MT) in 92 containers at LLNL;
- 28.1 kilograms (0.0028 MT) in 107 containers at Mound;
- 1.706 kilograms (0.0017 MT) in 83 containers at Oak Ridge;
- 1.4 kilograms (0.0014 MT) in 10 containers at Sandia National Laboratory; and
- 0.014 kilograms in 354 items at Lawrence Berkeley Laboratory.

Table 2.5 Plutonium in Oxides

Site	Pu Content, KG	# of Items
Rocky Flats	3200	3296
Hanford	1500	5100
Los Alamos	721	2000
SRS	800	800
Argonne-East	0.48	695
Livermore	102	92
Mound	28	107
Oak Ridge	1.7	83
Sandia	1.4	10
Lawrence-Berkeley	0.014	354
Total	6355	12537

Plutonium in Unirradiated Nuclear Fuel

As of June 2000, DOE had more than 50,000 items of clad, unused, unirradiated fuel containing a total of 4.4 to 4.6 MT of plutonium.

DOE's Office of Nuclear Energy retains control this plutonium. Until November 1999, the ZPPR fuels (Figures 2-4, 2-5) and FFTF Mixed Oxide (MOX) fuel (not pictured) were scheduled to be processed at the Plutonium Immobilization Plant at Savannah River Site. This idea was withdrawn in November 1999.

Processing 50,000 pieces of old unused fuel with high concentrations of americium-241 necessitated planning for remotely controlled processing of these materials. Plans for dealing with such highly radioactive materials greatly contributed to increased costs of a plutonium immobilization plant.

The cost of abandoning this path has not been determined. DOE is now considering calling the ZPPR fuel a "national asset material" but has yet to determine a future use.[11]

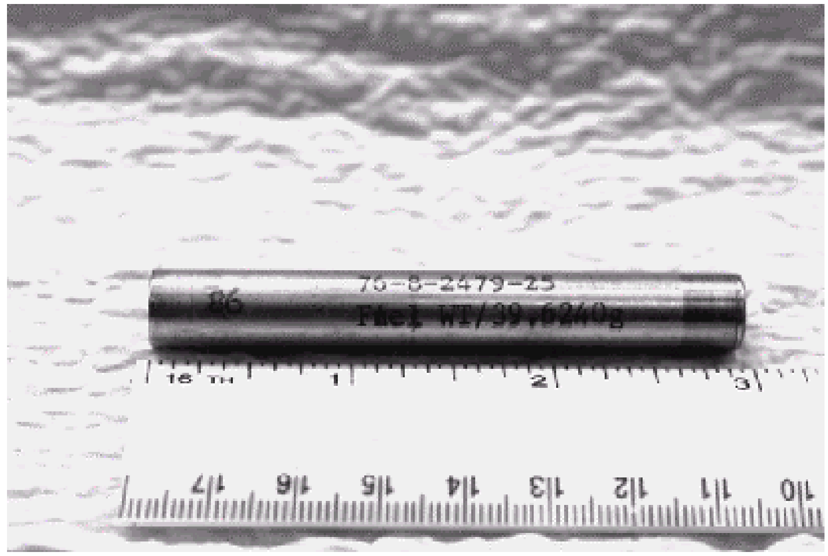


Figure 2-4. 21,000 ZPPR Fuel Pins like the one pictured here are stored at Argonne National Laboratory West, Idaho and contain a reported 0.3 MT of fuel-grade plutonium mixed with uranium oxide to make Mixed Oxide (MOX) fuel.

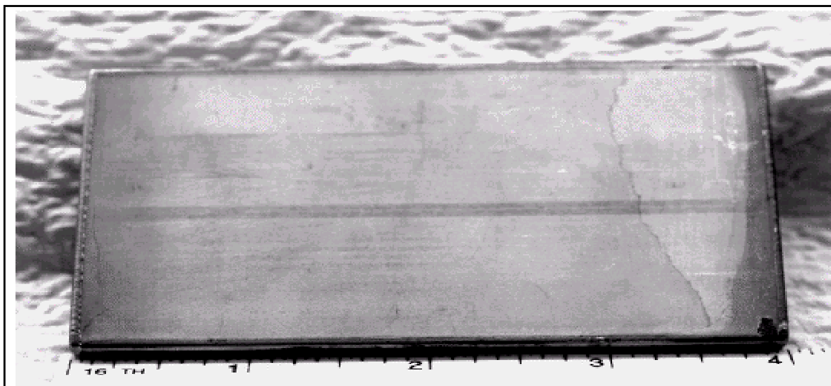


Figure 2-5. **ZPPR Fuel Plates**. 22,000 of these plates containing a reported 3.5 MT of plutonium are presently stored at Argonne National Laboratory-West within the Idaho National Engineering and Environmental Laboratory. The ZPPR fuel contains varying percentages of uranium and plutonium alloyed with either aluminum or molybdenum to make a material that is resistant to oxidation. Some plates are coated with nickel to increase the resistance to oxidation. Source: UCRL-ID-131608, Rev. 3, PIP-00-035

Plutonium Residues

Residues is a catch all phrase for "material containing plutonium that was generated during the separation and purification of plutonium or during the manufacture of plutonium-bearing components for nuclear weapons."[12] In 1990 these materials were assumed to have enough plutonium remaining to be recoverable for future operations. Today, the plutonium cannot be used in weapons without substantial processing and purification and it is mostly being treated as waste.

Residues currently consist of an estimated 6.350 MT of plutonium in 29,530 items:

- 3000 kilograms (3.0 MT) in 20,532 items totaling more than 100 metric tonnes of materials in Buildings 371 and 707 at Rocky Flats, of which nearly 10,000 items remain to be stabilized;
- 1,500 MT in 1300 containers at Hanford;
- 1,400 kg in nearly 6,000 items at LANL;
- 400 kilograms of plutonium in 1306 items of miscellaneous residues in the F-Area at the Savannah River Site;[13]
- 35 kilograms in 202 items at LLNL;(114 cans of ash)
- 3 kilograms in 39 items at Mound;
- less than 1 kilogram in 12 items at Argonne East;
- 0.1 kg in 12 items at Oak Ridge;
- less than 1 kg in 250 items at Lawrence Berkeley;

This is the least certain and most poorly defined of all categories for the following reasons:

1. With a few exceptions, this should be categorized as plutonium waste by U.S. standards, since DOE intends to "dilute" most of the residues to attain less than 10% plutonium by weight and therefore meet WIPP acceptance criteria. The desire to "bury" nearly 7 MT of plutonium that would be recycled under Russian policy clearly undermines claims made by U.S. plutonium fuel advocates that Russia opposes the U.S. burying plutonium, and therefore the U.S. must pursue the MOX plutonium fuel option.

2. Decommissioning of plutonium facilities across the nuclear weapons complex will result in more plutonium wastes. This is because the category called "holdup"–plutonium in pipes, glove boxes, ductwork, etc–has never been quantified and is considered part of the unaccounted-for plutonium.

3. A recent proposal by DOE and its labs, called the 2025 vision, holds open the prospects of processing much of the residues at the canyons at SRS in order to increase weapons grade plutonium inventories.

Table 2-6. Plutonium in Residues
Plutonium in Residues

Site	Pu Content, KG	# Items
Rocky Flats	3000	20532
Hanford	1500	1313
Los Alamos	1400	5900
SRS	400	1270
Argonne-East	0	12
Livermore	35	202
Mound	3	39
Oak Ridge	12	12
Sandia	0	0
Lawrence-Berkeley	0	250
Total	6350	29530

Plutonium in Waste:

In 1996 DOE estimated 3.4 MT of plutonium as "lost" through normal operations and categorized as plutonium wastes (not including plutonium released through smokestacks or in wastewater either routinely or by accident) that are buried or stored at 8 sites:

- 1.522 MT buried or stored at Hanford;
- 1.108 MT buried or stored at Idaho National Engineering Laboratory; with 0.002 MT of this credited to ANLW;
- 0.610 MT buried or stored at Los Alamos;
- 0.575 MT buried or stored at SRS;
- 0.047 MT buried or stored at Rocky Flats;
- 0.016 MT stored at Nevada Test Site from past nuclear weapons accidents;

U.S. Surplus Plutonium

U.S. surplus plutonium figures have changed substantially, although these changes are obscured by unclear management plans. In 1996 the U.S. declared 38.2 MT of weapon-grade plutonium to be surplus. The common belief is that the U.S. has 50 metric tonnes of surplus plutonium, but at no time did the U.S. declare an active inventory of 50 metric tonnes of weapons-usable plutonium.

2.1 MT of the non-pit weapon-grade plutonium is estimated to be nonsurplus based on the following:

- DOE declared 21.3 MT of plutonium at Pantex to be surplus, leaving 44.8 MT of plutonium in pit form as stockpile plutonium;
- DOE declared 38.2 MT of weapon-grade plutonium to be surplus, leaving 46.9 MT of weapon-grade plutonium as nonsurplus;

The Nominal 50 MT

This confusion is a function of DOE planning efforts. The Office of Fissile Materials Disposition spent five years conducting environmental impact statements (EIS) on the plutonium disposition options. The EIS processes consistently used 50.0 metric tonnes of surplus plutonium as a "nominal planning figure,"[14] broken down as:

- 31.8 MT of "clean metal," mostly plutonium contained in weapon components (pits), designated to the MOX route;
- 18.2 MT of plutonium contained in an array of forms considered physically unsuitable or economically unfeasible to separate and purify for use in MOX and designated for the immobilization disposition route.

Several assumptions lie within the "nominal planning figures (figure 2-6):

- materials will be pre-processed before the disposition steps begin. In other words, the planning figures are based on expected conditions, not real conditions.
- included was 7.0 MT of metals "anticipated" to be surplus if START II induced more weapons dismantlement;
- not included was the 7.5 MT of plutonium in irradiated fuel.

Feed Projection Categories	Plutonium Mass (MT)
Clean Metal (including pits)	31.8
Impure Metal	3.4
Plutonium Alloys	1.0
Clean Oxides	1.7
Impure Oxides	6.4
Uranium/Plutonium Oxides	0.9
Alloy Reactor Fuel	3.5
Oxide Reactor Fuel	1.3
Total	50.0

Figure 2-6. Projected Feed for Plutonium Disposition.

The Real Surplus

DOE did report approximately 52.5 metric tonnes (MT) of surplus plutonium (see Table 1-5) that included:

- 38.2 MT of weapons-grade plutonium and 14.3 MT of fuel-grade plutonium.
- A net amount of surplus weapons-usable plutonium in the existing inventory of 43.0 MT.[15]

The 9.5 MT of plutonium not weapons-usable in its present state, broken down as:

- 7.5 MT of plutonium contained in irradiated mixed-oxide (MOX) and metal alloy fuel that already met the spent fuel standard.
- 2.0 MT of material commonly known as "residues" with low concentrations of plutonium for "which extraction of plutonium would not be practical and which is expected to be processed and repackaged for disposal as TRU [transuranic] waste" at the Waste Isolation Pilot Plant in New Mexico.

The Changing Surplus

The following changes have occurred since the surplus inventory was announced:

1. There is now 3.0 MT of plutonium in residues scheduled for disposal at WIPP and this material is identified as weapon-grade plutonium.. The addition of 1.0 MT to this route occurred when DOE rescinded its decision to send 1.0 MT of plutonium in Rocky Flats "Sands, Slags, and Crucibles" to the reprocessing canyons at SRS.

2. In 1997 Lawrence Livermore National Laboratory reported only 51.3 MT as the "latest estimate"[16] of surplus plutonium within a table identical to one in 1997,[17] with the difference being the removal of 1.2 MT of plutonium in the following forms:

- 0.8 tonnes of fuel-grade plutonium in irradiated fuel;
- 0.2 MT tonnes of fuel-grade plutonium in unirradiated reactor fuel;
- 0.1 MT of fuel-grade plutonium oxide;
- **0.1 MT of weapon-grade plutonium metal;**

The reasons for this change are unknown and have not been explained by DOE. However, in 1998 plutonium pits were reclassified (see Part 3) and some surplus pits were reidentified as "national assets." Also, in 1998 Los Alamos received "permission from the politicians" to divert some "nickel-sized" pieces of plutonium from its pit disassembly and conversion "disposition" demonstration project to its nuclear weapons program for plutonium aging studies.[18]

3. In November 1999, prior to issuing a Record of Decision on the SPDEIS in January 2000, but after finishing the final SPDEIS, DOE removed the unirradiated ZPPR fuel plates and oxides pins from the surplus inventory and declared it "Programmatic Use material."[19] DOE failed to mention this change in its Record of Decision and apparently did not inform the designers of the Immobilization Facility until after January 1, 2000. [20]

In June 2000 DOE submitted its Integrated Nuclear Materials to Congress in which they described an active surplus plutonium inventory of 52.5 MT but added the disclaimer that "a majority of the excess, approximately 48 MT, has no programmatic use." DOE then described how it removed more than 4 MT from the surplus inventory:

"*A small portion of the 52.5 MT supports programmatic uses such as basic scientific research, criticality research, and production of medical isotopes. Most of this is in the form of fuel for the Zero Power Physics Reactor (ZPPR) and Fast Flux Test Facility (FFTF).*"

"The Department is now considering retaining the ZPPR fuel as a national resource at ANL–W. The Department is currently preparing a Programmatic Environmental Impact Statement (PEIS) (DOE, 1999i) to consider the potential impacts of expanded nuclear facilities to accommodate new civilian nuclear energy research and development efforts and isotope production missions, including the role of the FFTF." [21]

Table 2-3 of this document identifies the ZPPR fuel as "in storage pending future use."

The U.S. Russian Agreement

Adding to the confusion is the U.S./Russian bilateral plutonium disposition agreement signed on September 1, 2000. Plutonium "disposition" is a catchphrase for putting plutonium in a highly irradiated storage environment. Instead of 50 MT to be "disposed," the agreement calls for only disposing 34.5 MT. DOE has continued to incorrectly declare 52.5 MT of surplus plutonium in the active inventory (see Figures 2-7 and 2-8 on following page).

One unfortunate consistency in plutonium management has been overlapping and poorly integrated bureaucracies. DOE's Office of Fissile Materials Disposition (OFMD) and the Office of Environmental Management (EM) have never presented a cohesive plan for managing non-pit plutonium to the public, and they can't seem to agree on the numbers:

- EM incorrectly described the 14.3 MT of non-weapon grade plutonium as "non-weapon-capable" even though DOE defines weapons-usable as *"all plutonium except that present in spent [irradiated] fuel and plutonium which contains greater than 10% plutonium 238."*[22]
- Although WIPP was never said to be part of the fissile materials disposition program in terms of surplus plutonium, both parties show 3.1 MT of weapons-grade plutonium being disposed of at WIPP. OFMD's chart states the material will be "diluted in waste" and sent to WIPP; whereas the EM chart simply shows this waste being sent to WIPP;
- EM inaccurately claimed that 4.8 MT of reactor fuel was surplus.

Table 2.7. Non-pit Plutonium Inventory		
Plutonium Form	# Items	Plutonium Content, MT
Metals	6361	8.59
Oxides	12537	6.35
Residues	29530	6.35
Unirradiated Fuel	52,000	4.6
Total	100,528	25.9

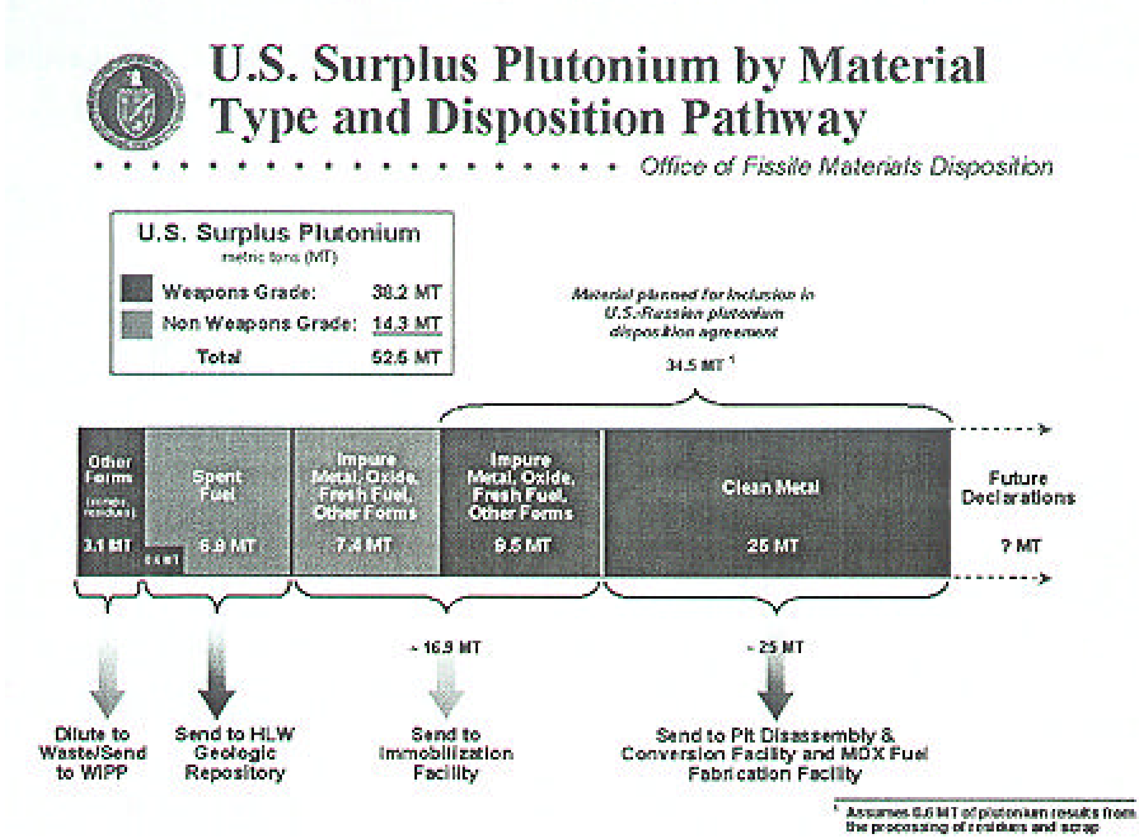


Figure 2-7. Office of Fissile Materials Disposition

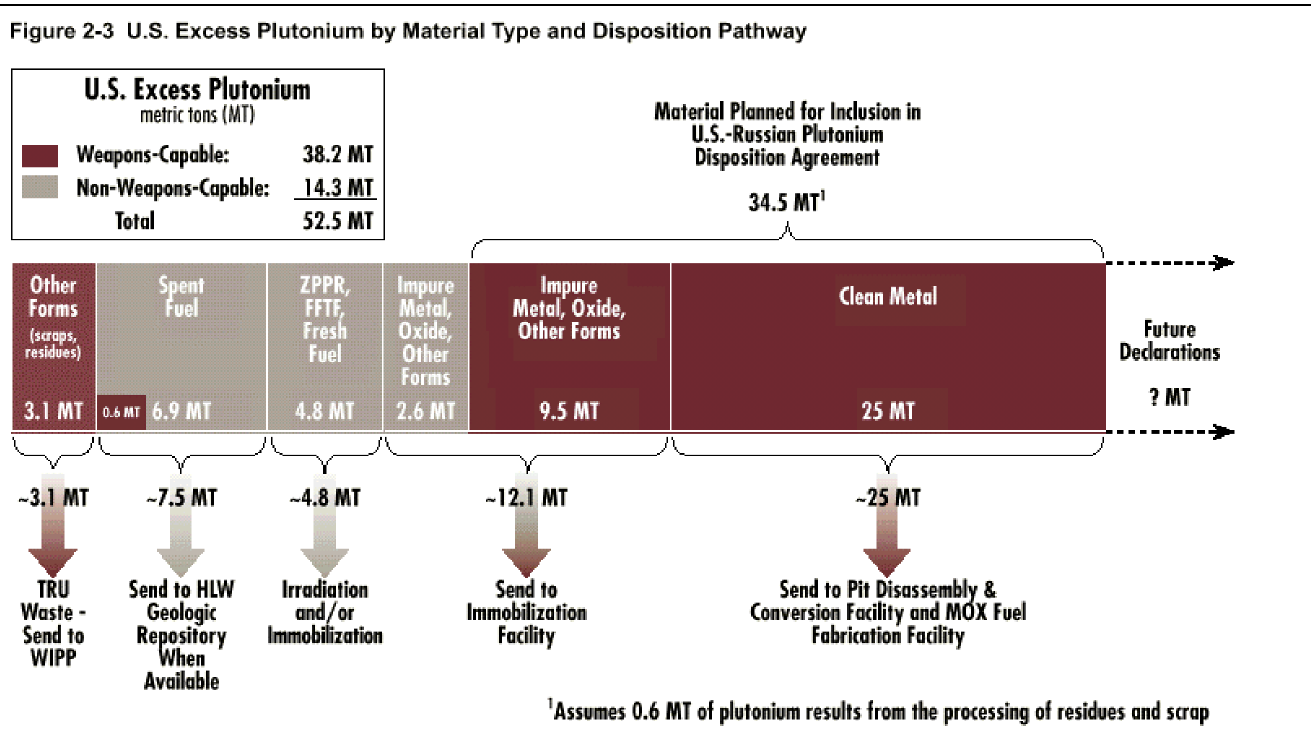


Figure 2-8. Office of Environmental Management.

Table 2-8. DOE's Variety of Surplus Plutonium Numbers

Form	DOE's Official Estimate of Surplus Pu			"Planning" Estimate of Surplus Pu Total**	Amount for Disposition under U.S./Russia Agreement
	Weapon-Grade	Fuel-Grade	Total*		
Metal	27.8	1.0	28.9	(1) 36.2	27.8
Oxide	3.1	1.3	4.4	9.0	3.1
Reactor Fuel	0.2	4.4	4.6	4.8	0.0
Irradiated Fuel	0.6	6.9	7.5	0	0.0
Other Forms	6.4	0.7	7.1	0	4.6
Totals	38.2	14.3	52.5	50.0	34.5

*Metal includes plutonium in pits, ingots, and buttons; Oxide refers to plutonium oxide, reactor fuel refers to prepared but unused MOX fuel, metal-alloy fuel elements, pellets, and MOX powder; and "other forms" refers to uranium/plutonium oxides and "residues" from the fabrication of weapon components.

(1) This includes 7.0 MT "that may be declared surplus in the future."
(2) In 1997 DOE reported that 0.223 MT of plutonium/uranium fuel material that had not been fabricated into finished fuel components is part of the 4.8 MT total of unirradiated fuel and therefore **accounted for an additional 0.2 MT of reactor fuel in the planned category;**[23]

Table 2-9. BREDL's Estimate of Active U.S. Plutonium Stockpile

Form	BREDL's Current Estimate of Surplus Pu			Stockpile Pu			Amount for Disposition under U.S./Russia Agreement
	Weapon-Grade	Fuel-Grade	Total*	wg	fg		
Metal in Pits	21.2	0	21.2	44.9	0	44.9	21.2
Clean Metal	3.7	0	3.7	2.1	0	2.1	3.7
Oxide	3.1	1.6	4.7		0		4.7
Impure Metal	2.8	1.0	3.87	0	0	0	2.8
Reactor Fuel	0	0.0	0.0	0.2	4.2	4.4	0.0
Irradiated Fuel	0.6	6.1	6.7	0	0.8	0.8	0.0
Residues	6.5	0.7	7.2	0	0	0	0.4
Totals	37.9	9.4	47.3	47.2	5.0	52.2	31.8

Nuclear Site	Total Plutonium Inventory, in Metric Tonnes (1.1 English Ton = 1.0 metric tonne) and by material						
	Metal	Oxide	Residues	Solutions	Reactor Fuel	Irradiated Fuel	Total
Hanford (1)	0.7	1.5	1.5	0.343	0.6	6.6	11.243
ANLW	0.1	0	0	0	3.8	0.1	4.0
INEEL	0	0	0	0	0	0.5	0.5
SRS (2)	0.490	0.800	0.400	0.110	0	0.3	2.1
PANTEX (3)	66.1	0	0	0	0	0	66.1
LANL (4)	1.1	0.7	1.4	0	0	0	3.2
LLNL (5)	0.020	0.102	0.035	0	0	0	0.4
RFETS (6)	6.6	3.2	3.0	0.043	0	0	12.9
Totals (7)	75.13	6.35	6.35	0.496	4.4	7.5	100.2

(1) DOE reported 11.0 MT in 1996. The plutonium in solutions may be double counted.
(2) Does not reflect plutonium received from Rocky Flats, which could bring total as high as 2.5 MT.
(3) This is total plutonium at Pantex plus in weapons stored or deployed. There are 12,000+ plutonium pits presently in storage, with approximate on-site inventory of 35 to 40 MT. The total inventory of plutonium in pits has probably been reduced by up to 0.5 MT due to stockpile surveillance and pit disassembly and conversation demonstration project at Los Alamos.
(4) Does not reflect the plutonium Los Alamos has from Rocky Flats and from Pantex.
(5) Probably reflects plutonium shipped from Rocky Flats.
(6) 1,200 plutonium pits were transferred to Pantex with no decrease in inventory means that plutonium in pits were not part of declassified inventory at RFETS. 0.1 MT of Pu in solutions were converted to oxides, not reflected here.
(7) Higher total may mean that plutonium in solutions is double counted and reported as oxide or metal by DOE.
Other sites include Sandia, Oak Ridge, Mound, Argonne-East, and Lawrence Berkeley Laboratory, and amount to <0.1 MT.

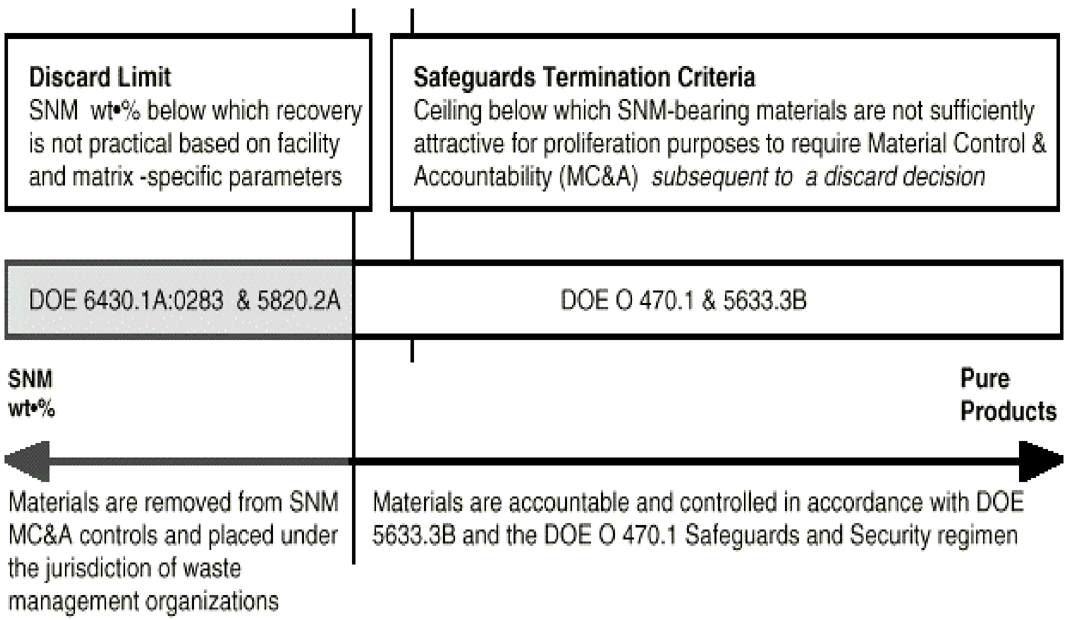
1. U.S. Department of Energy. *Plutonium. The First 50 Years.* DOE actually declared 99.5 MT but this did not include 0.1 MT of "classified transactions."

2. Inventory Differences used to be called "Materials Unaccounted For"

3.Savannah River Site FY 2001 Annual Operating Plan. *Summary Task Description Sheet*. SOXX. MC&A.

4. http://www.ieer.org

5. This graphic illustrates the fine line between "waste" and "residues." Historically much of what is now called "residues" would have been recovered by purifying the plutonium. Russia's policy is to recover plutonium from all forms until there is less than 200 ppm of plutonium remaining. Only then does it become a waste.



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8. Defense Nuclear Facilities Safety Board. Recommendation 94-1. May 26, 1994.

9. U.S. DOE. Implementation Plan for DNFSB Recommendation 94-1. February, 1995.

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11.U.S. DOE. 2000. *Integrated Nuclear Materials Management Plan.* Submitted to Congress, June 2000.

12.DOE 94-1 Implemnetation Plan. Revision 3.

13.DNFSB. Recommendation 2000-1.

14.U.S. DOE. Office of Fissile Materials Disposition. *Draft and Final Surplus Plutonium Disposition Environmental Impact Statements (SPDEIS)*, 1997-1999.

15. U.S. DOE. Office of Fissile Materials Disposition. 1997. *Feed Materials Planning Basis for Surplus Weapons-Usable Plutonium Disposition.* April 1997.

16.

Table 1: *Current Surplus Plutonium*

Category	Weapons-Grade Plutonium	Non-Weapons-Grade Plutonium	Total Surplus Plutonium
Metal	27.9	1	28.9
Oxide	3.1	1.3	4.4
Reactor Fuel	0.2	4.4	4.6
Irradiated Fuel	0.6	6.9	7.5
Other Forms	6.4	0.7	7.1
Total	38.2	14.3	52.5

Table 1. Composition of United States Surplus Plutonium by Form and Grade

Form	Weapon-Grade[1]	Fuel-Grade[2]	Total
Metal[3]	27.8	1.0	28.8
Oxide[4]	3.1	1.2	4.3
Reactor Fuel[5]	0.2	4.2	4.4
Irradiated Fuel[6]	0.6	6.1	6.7
Other Forms[7]	6.4	0.7	7.1
Totals	38.2	13.2	51.3

Footnote 16: Feed Materials Planning Basis. 1999. Note that only 38.1 MT of weapon grade is considered, although the author inserted 38.2 in the bottom column.

18. Olivas. Plutonium Aging.

19.Letter, William D. Magwood, DOE, Office of Nuclear Energy, to Laura S. H. Holgate, DOE, Office of Fissile Materials Disposition, "Zero Power Physics Reactor (ZPPR) Plutonium Fuel," November 12, 1999.Referred to in the November 2000 SRS Pu Storage Plan.

20. *Design Only Conceptual Design Report for Plutonium Immobilization Plant*. February 2000. Revision 1.

21.*Integrated Materials Plan*. Page 2-4.

22. Gray, L.W. et al. 1999. *The Blending Strategy for the Plutonium Immobilization Program*. Paper prepared for submittal to the Waste Management '99 Symposium, Tuscon, Arizona. February 28-March 4, 1999. UCRL-JC-133279. Lawrence Livermore National Laboratory.

Part III
Plutonium in Pits

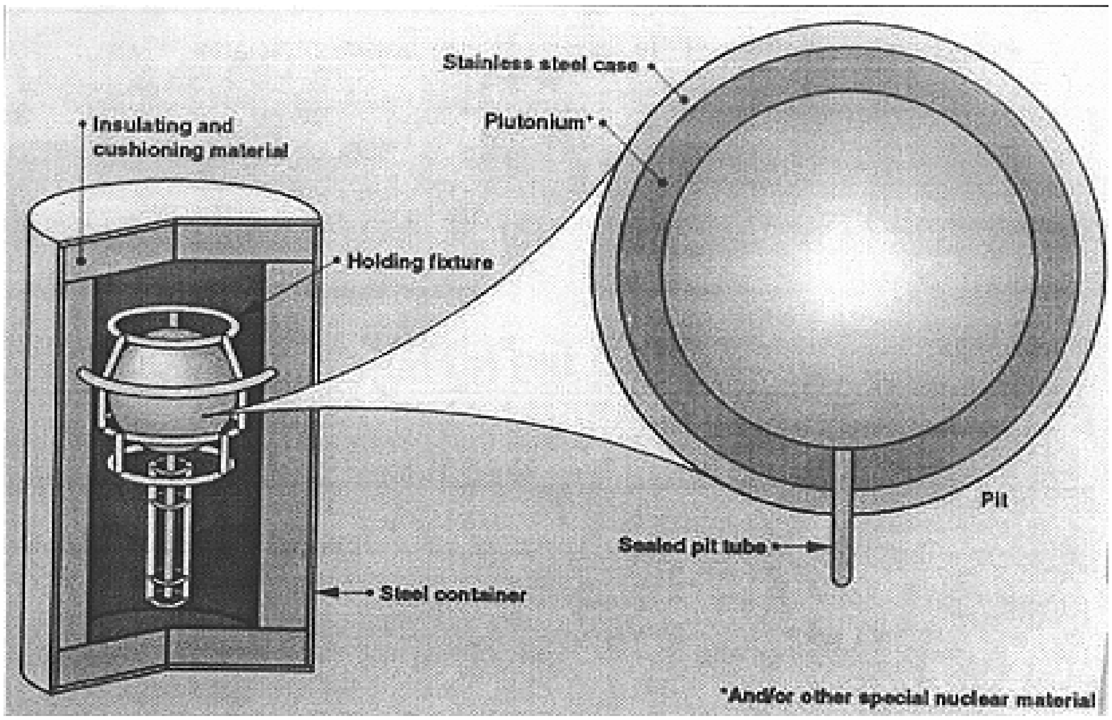

Figure 3-1. Simplified illustration of a plutonium trigger, or "pit", with storage "AL-R8" storage container. Source: U.S. Department of Energy (DOE), Office of Fissile Materials Disposition (OFMD). http://www.md.doe.gov

Plutonium pits are finished weapon components and comprised of numerous parts, including metal cladding, welds, a pit tube, neutron tamper(s), and plutonium hemispheres (usually hollow-cored). The sealed pit tube carries deuterium-tritium gas into hollow-core pits in order to boost the nuclear explosive power of weapons.

This illustration shows stainless steel as the outer cladding, but some pit types are also clad with beryllium, aluminum, and possibly vanadium; and there are experimental designs called "not war-reserve like" pits stored at Rocky Flats in Colorado.

There are more than 12,000 plutonium pits stored at the Pantex Nuclear Weapons Plant near Amarillo, Texas - - of which 7,000 to 8,000 are "surplus"- - and another 8-10,000 stored in nuclear weapons, both deployed and stored.

Plutonium Pit Basics

Plutonium pits are the triggers in most nuclear explosives. Pits are sealed weapon components containing plutonium and other materials and came into being in 1956, replacing the plutonium "capsule" trigger design.[1] Pits are surrounded by carefully machined high explosive spheres. When the high explosives are detonated the plutonium is compressed and imploded, thus triggering the nuclear detonation (see Figure 1-1).

Pits were fabricated at the Rocky Flats plant in Colorado from about 1954 to 1989, when safety and environmental problems forced a production shutdown. Rocky Flats is infamous for thirty five years of unsafe operations and costly accidents resulting in massive radiological contamination, but in the nuclear weapons complex it is equally known for producing high quality, "diamond-stamped" plutonium pits considered the most durable and resilient parts of nuclear weapons.

There are about 48 different types of pits (see Table 3-1), each designed for use in specific nuclear weapon systems and to be stored for 20 years or more inside a weapon environment. Long-term storage (more than five years) of pits outside of weapons is a program filled with uncertainties. Designers and weaponeers within DOE refer to the variety of designs in terms of "pit families,"with some more important variations including:

- shape and mass of the plutonium within the pit;
- the presence or absence of highly enriched uranium;
- the presence or absence of tritium;
- the type of metal cladding;
- bonded vs. nonbonded.

Describing Pits, No. 1

"Pits can generally be characterized as nested shells of materials in different configurations and constructed by different methods."

Los Alamos National Laboratory. ARIES Fact Sheet. 1997.

Describing Pits, No. 2

Rocky Flats described pits as a "pressure vessel designed to withstand, without yielding, the boost gas or other operational pressures which vary from weapon to weapon but are in the range of hundreds of psi."
Pits are also "designed to provide containment of the radioactive materials to prevent the release of contamination or other unsafe conditions." Other features of pits include:

- all metal construction generally using three joint welds at the "equator," the tube pinch-off, and the tube to shell brazed joint;
- an absence of o-rings, seals, or other non-metallic components which are sensitive to either heat or cold.

Source: *Safety Analysis Report for the AL-R8 Container*. Rocky Flats Plant. 1990.

Pit numbers and DOE management terminology

Normal operations coupled with START I treaty between the U.S. and Russia turned the Pantex nuclear weapons plant into a disassembly facility in the 1990's (Figure 3-2). 11, 875 weapons were dismantled, with most of the plutonium pits being sent to "Zone 4" for "interim" storage.[2] More than 11,000 plutonium pits accumulated at Pantex during this time, (Figure 3-2).

About 1200 pits were shipped to Pantex between 1997 and 1999 from Rocky Flats, and another 60 pits were shipped from SRS to Pantex in 1998. Pantex in turn shipped about 20 pits/year to Los Alamos for its surveillance/inspection program, and an undisclosed amount (but less than 100) to Los Alamos for plutonium pit disassembly and conversion demonstration program, leaving more than 12,000 pits at Pantex today.[3]

DOE now categorizes pits as surplus to military needs or as "national security assets" (NSA), the latter a category concocted in 1998 and composed of:

- strategic reserve pits, including surplus pits considered defense program "assets;"
- "enduring stockpile" pits that belong to existing weapon systems;
- "enhanced surveillance" pits that may include surplus pits.[4]

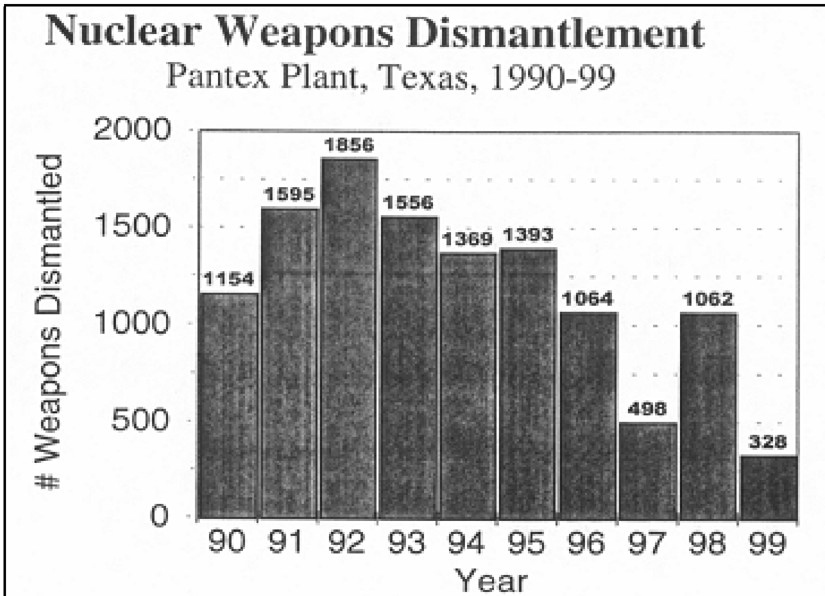

Figure 3-2. Weapons Dismantlement at Pantex, 1990's. (427 dismantlements were scheduled for Year 2000).

National Asset pits are scheduled to be stored indefinitely at Pantex in retrofitted Building 2-116, possibly the most robust facility at Pantex but not one without problems. At least one "national security asset" pit, the problematic W-48, is not allowed in 12-116 because of heat concerns; and there is no funding to move the national asset pits into 12-116 this fiscal year.[5]

The list of NSA pits is not constant, and the "design agencies"–Lawrence Livermore and Los Alamos National Laboratories--have failed to update their list of *national security assets* since February 1999, leaving Pantex in the dark:

> "*an updated list has been requested by letter, in briefings, and verbally to the person in charge of the list. To date, an update has not been received. This is an open issue.*" [6]

The total amount of plutonium in surplus pits was declared to be 21.3 MT in 1996. DOE maintains this number is current, but the reclassification of some surplus pits as "national assets" leaves this questionable. If START II arms reductions are implemented, another 7.0 MT of surplus plutonium in about 2,000 to 2,500 pits is likely to be declared.

Surplus pits are scheduled to remain in Zone 4 at Pantex (see Pit Storage at Pantex, page 3.) until they are sent to a Plutonium Pit Disassembly and Conversion Facility (PDCF) scheduled to open later this decade at Savannah River Site. (SRS). Plutonium pit disassembly and conversion refers to "the removal of the plutonium from the nuclear weapon pit and conversion [of the plutonium and other parts] to an unclassified form that is verifiable in the sense that, containing no classified information, the form can be examined by inspectors from other nations."[7] Size, shape, mass and isotopic composition of the plutonium and other parts are considered traits in need of declassification at the PDCF.

Table 3.1 Plutonium Pit Types in U.S. Nuclear Weapons "Enduring Stockpile."

Designer Laboratory	Warhead	Pit Type (# ID[89]	Container	Unique Properties and/or Safety Issues
Los Alamos National Laboratory	B61-3,4,10	123	2040	Present container unsuitable for long-term storage. (See Pit Storage, Page 3). B61-4 also reported as Pit Type 118
	B61-7,11	125	2040	
	W76	116	2030	Most heat sensitive LANL design
	W78	117	2030	
	W80	124	2030	Responsibility being transferred to LLNL
	W80	119	2030	
	W88	126	2030	
Lawrence Livermore National Laboratory	B83	MC3350	MODF	Heaviest Pit[10] , Fire Resistant Pit
	W62	MC2406	2030	
	W84	(1)	unknown	Fire Resistant Pit
	W87	MC3737	2040	Fire Resistant Pit. Unsuitable container.

Container refers to the AL-R8 Subtype[11]. There are no replacements for the 2040 at this time.
Pit type ID's were determined from 1990 Rocky Flats Safety Analysis Report for AL-R8's and from Dow and Salazar. Re: *Storage Facility Environmental Requirements for Pits and CSA's.* August 22, 1995.
(1) One high numbered LLNL pit, the MC 3650, was reported by Rocky Flats to have the highest heat load of any pit, including surplus pits. This could be the W84.

Table 3.1.B: Plutonium Pit types from retired weapon systems.

Design Lab	Warhead	Pit Type	Container	Unique Properties and/or Safety Issues
Los Alamos	B28	83	2030	
	B28-0	93	2030	minimum decay heat load[12]
	B43	79	unknown	Beryllium cladding
	B43-1	101	2030	Beryllium cladding
	W33	Unknown		
	W44	74	2030	Beryllium cladding
	W44-1	100	2030	Beryllium cladding
	W50	92	unknown	
	W-50-1	103	2030	
	B54	81	2030	Pits require cleaning[13]
	B54-1	96	2030	Pits require cleaning
	B57	104	2030	
	W59	90	unknown	
	B61-0	110	2030	
	B61-2,5	114	2040	Unsuitable container, no replacement yet
	W66	112	unknown	
	W69	111	2030	
	W85	128	2030	
Lawrence Livermore National Laboratory	W48	MC1397	2030	Beryllium clad pits, require cleaning prior to LTS
	W55	MC1324	2030	Suspected to be beryllium clad
	W56	MC1801	2040	High radiation pits, require cleaning prior to LTS
	W68	MC1978	2030	
	W70-0	MC2381	2030	
	W70-1	MC2381a	2030	
	W70-2	MC2381b	2040	Unsuitable container with no replacement yet
	W70-3	MC2381c	2060	Suitability of container
	W71	Unknown		Pits require cleaning
	W79	MC2574	2030	Suspected to be beryllium clad

Plutonium Mass, Beryllium, and HEU

The amount, or mass, of plutonium that is inside of a pit varies and even the average amount remains classified. But enough evidence exists to declare a range of 1 to 6 kilograms (2.2 to 13.2 pounds) of plutonium mass in pits. Only one kilogram of plutonium is necessary for a 1 kiloton explosion,[14] and Los Alamos defined a maximum material weight of 6 kilograms in pit shipping containers.[15] Considering there is 66.1 MT of plutonium in approximately 20,000 plutonium pits, the average plutonium content is just over 3.0 kilograms per pit, or 6.6 pounds.

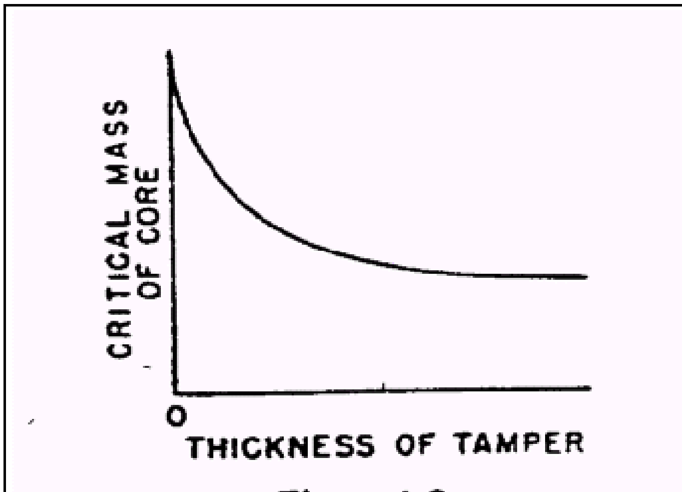

Figure 3-3. Plutonium mass in pits is reduced through the use of neutron tampers. Source: *An Introduction to Nuclear Weapons*. 1972.

Two design variations can be used to decrease the plutonium mass:

1. Neutron tampers (Figure 3-3) are used to scatter escaping neutrons back into the plutonium or HEU core after the nuclear chain reaction starts.[16] One of the more common neutron tampers is beryllium, a highly toxic light metal. Because classified nonnuclear pit parts will be "declassified" at a PDCF by using furnaces to melt down the classified shapes,[17] this operation poses extreme workplace hazards when the tamper is high-purity beryllium (Figure 3-4).

Figure 3-4. How Toxic is Beryllium?
According to the Lawrence Livermore National Laboratory Health and Safety Internet Site, "some people are very susceptible to getting Chronic Beryllium Disease" when inhaling small amounts of beryllium dust. Acute Beryllium Disease can "cause toxic reaction to the whole body " if large amounts are inhaled.
(http://www-training.llnl.gov/wbt/hc/Be/Hazards.html)

2. The use of Highly Enriched Uranium (HEU), also known as "Oralloy, in pits creates what are referred to as "composite cores" and were a "major advance" in weapons design that reduced the probability of pre-initiation of the nuclear explosive, and allowed for a reduction in the amount of plutonium in the pit.[18] As a result, "the pits in the US stockpile can be generally grouped into two types: (1) those containing weapons-grade plutonium and (2) those containing weapons-grade plutonium and highly enriched uranium."[19]

The presence of HEU in pits poses accounting, handling, and classification problems at a PDCF. In 1998 the ability to perform adequate materials control and accounting measurements on incoming pits was found to pose a technically high risk at the planned PDCF.[20] This risk is higher with HEU pits since there are no "proven techniques for measurement" of this type.[21]

Having HEU parts in plutonium pits also necessitates decontamination of the HEU to levels that meet strict acceptance criteria at the Y-12 plant at Oak Ridge, Tennessee. The Y-12 plant is responsible for all storing all military HEU, it is not a plutonium processing site, and designation as such would meet stiff and justifiable resistance from the state and local communities.

Los Alamos encountered difficulties meeting the previous criteria of 20 disintegrations per minute of plutonium 239 in HEU metal, "with 30% of the shipped parts presently being returned." However, the new limit for plutonium contamination in HEU-oxide form has changed to 2.7 parts-per-million, allowing plutonium levels "several orders of magnitude" higher than the metal standard.[22]

Because of this issue, the final form of the HEU at a pit disassembly and conversion plant was undecided as of a year ago. The decontamination methods under consideration include:

- electrolytic etching, the current method at LANL that has achieved marginal success at meeting metal acceptance criteria at Y-12 but generates less waste;
- Acid spray-leach; the historical process that involves spraying parts with acid and then soaking in a diluted acid solution for up to three hours, producing large volumes of liquid waste; or
- brushing of parts with a wire brush or blasting parts with "some medium," both of which "are not expected to achieve the Y-12 acceptance criteria."[23]

Plutonium Shape

Because the critical mass for a spherical shape is "less than for any other geometrical form of the given material,"[24] most pits are reported said to be spherical in shape. It is unlikely that plutonium in pits are only spherical:

- Passive NMIS measurement systems are in development to estimate the shape of plutonium assemblies inside of containers.[25]
- DOE continues to censor the discussion of shape of critical masses in the sanitized version of *Introduction to Nuclear Weapons* (Section 1.22).[26]
- Criticality experiments at Rocky Flats in the 1960's included cylindrical shapes of plutonium..[27]

Isotopic Composition

The amount of Plutonium-240 is the key isotopic variable in weapon-grade plutonium because its high rate of spontaneous fission poses a higher risk of "pre-initiation," or an early chain reaction, of the fissile material. Higher quantities of plutonium-240 mean increases in critical mass requirements, and therefore costs more to design, develop, and produce the warhead.[28] Early weapons had plutonium-240 content as low to 1.5% but more commonly 4-7%; and in 1972 the Pu-240 content in most stockpile weapons was said to be about 6%.[29] The isotopic composition varied slightly according to the source of the plutonium (Figure 3-5) and the design of the pit.

Table 1.5 COMPOSITION OF WEAPONS-GRADE PLUTONIUM IN WEIGHT PERCENT

	Hanford	Savannah River
Plutonium-238	<0.05	<0.05
Plutonium-239	93.17	92.99
Plutonium-240	6.28	6.13
Plutonium-241	0.54	0.86
Plutonium-242	<0.05	<0.05

Figure 3-5. Variation in average isotopic composition by source.
From: *An Introduction to Nuclear Weapons*. 1972.

During five years of Environmental Impact Statements, DOE never informed the public that declassification of pits included declassifying the isotopic composition. One month after the January 2000 Record of Decision to build a PDCF at SRS was signed, the "blending" of plutonium oxides from two or more pit types was required to declassify the isotopic composition of the powder.[30] It is unclear whether this requirement is an artifact of the Atomic Energy Act or a requirement for the plutonium fuel factory.

Cladding and Beryllium Problems

Plutonium pits have an outer cladding of beryllium, aluminum, or stainless steel. Vanadium is another cladding element, but it is unknown whether it is just experimental or in use. Vanadium was used in 1993 during the W89 pit re-use program at Pantex as a fire resistant cladding on W68 pits being converted for use as W89 pits,[31] and the classified plutonium part inventory at RFETS presently includes six Pu/Vanadium hemishells.[32]

At least seven pit types are known or suspected to be clad with beryllium. (Table 3.1.B), [33] posing the most significant problems with storage and dismantlement of pits:

The W-48

The pit for the W-48 nuclear artillery shell is a clad with beryllium, and has created great problems at Pantex. In 1992 a W48 pit cracked during a Pantex weapon disassembly operation that required rapid cooling followed by rapid heating during removal of the high explosives. The crack of 0.025 inch wide and 8.0 long in the outer beryllium shell resulted in airborne plutonium contamination and was one of the rare accidents involving pits. Afterward, a summer temperature limit of 150 degrees was established for W-48's. In spite of these problems, DOE is retaining an undisclosed number of W-48 pits as National Security Assets.

- pit disassembly can expose workers to highly toxic beryllium dust and fumes;
- beryllium clad pits appear to be more likely to require cleaning (see Table 3.1.B to remove any potentially corrosive organic materials, and pit cleaning can expose workers to airborne beryllium;
- higher sensitivity to temperature fluctuations;
- increased risk of corrosion from chlorides and moisture which are found in storage containers;
- pits clad with beryllium "are more vulnerable to fracture under impact loading."[34]

Pits as a Heat Source

Many pits are sensitive to temperatures, particularly those clad with beryllium. Los Alamos and Lawrence Livermore have expressed major concerns over heating of pits since early this decade.[35] In 1995 Lawrence Livermore and Los Alamos National Laboratories recommended temperatures between 65 and 75 degrees Fahrenheit for storage buildings with strategic reserve pits, and less stringent recommendations for "surplus" plutonium pits.[36]

In August 1998 an estimated thirty plutonium "W76" pits were moved from one Pantex Zone 4 "bunker" to another "due to potential temperature concerns during the recent heat wave."[37] The W76 pits are part of the large "strategic reserve"of pits scheduled to be stored indefinitely at Pantex.

Pits that Heat Up

"Because of natural radioactive decay, each plutonium pit is an intrinsic heat source, producing as much as roughly 18 watts in heat load. Currently, magazine heat loads at Pantex can reach as high as a few kilowatts-an amount sufficient to raise internal magazine temperatures well above ambient. Elevated magazine temperatures are a cause of concern because of corresponding elevations in pit temperatures. Because the AL-R8 containers are primarily designed to keep heat from external sources from entering the pit and to protect the pit in the event of a fire, their design also serves to prevent heat produced by the pit from escaping. Thus, depending on pit wattage, relatively high differences in temperature (ATs) from pit to can can occur. Some high-wattage pits, with average temperatures greater than 50 degrees C, are known to have reached temperatures near 150 C while stored in Zone 4." Source. **Pit Storage Monitoring**. 1995.

Tritium in Pits

In 1998 Los Alamos released a fact sheet that stated:

"*A significant number of pits processed by the ARIES facility will contain tritium.*" [38]

The "fact that tritium is associated with some unspecified pits" was declassified in 1992.[39] During the Environmental Impact Statements for plutonium disposition, DOE vaguely admitted that some plutonium pits were "contaminated" with tritium and that these pits would have to be decontaminated; but finally acknowledged that some pits contain tritium by writing:

"*DOE knows how many pits contain tritium.*"[40]

The reason for having tritium in pits by design is unknown but the impacts of this design on the disassembly of plutonium pits are now more open.

Pits that contain tritium must be processed up-front in a highly secretive "Special Recovery Line" where plutonium "is separated from highly enriched uranium (HEU) and other parts and then processed in a vacuum furnace that drives off tritium and produces a metal ingot. The tritium is captured and packaged as a low level waste. The resulting plutonium ingot is assayed and then reprocessed if it still contains tritium."[41] This process was sufficiently difficult enough to dissuade Los Alamos from processing pits containing tritium in its original ARIES demonstration project when only 40 pits were planned for disassembly and conversion.[42]

The major environmental impact of this process is tritium air pollutants. In the June 1998 Environmental Assessment for the plutonium pit demonstration project at Los Alamos involving 250 plutonium pits over a four year period, DOE reported air emissions of "up to 69 curies of tritium each year." In the 1998 Draft SPDEIS, DOE buried the impacts in a source document by choosing to omit a small table occupying less than a half-page reporting that 1100 curies of tritium will be emitted annually at a PDCF.[43]

Tritium Contamination vs. Pits that contain tritium

Pits could become contaminated if they contain tritium by design, or if they become contaminated with tritium by accident. In any case, any kind of hydrogen-plutonium reaction is undesirable because it could induce hydride corrosion of the plutonium metal, causing pitting and a growth of hydride film along the surface,"[44] as well as producing a pyrophoric plutonium hydride compound.

> "Hydride corrosion of uranium and plutonium may have significant implications for the lifetime of uranium [and plutonium] in nuclear weapons."
>
> *A Model for the Initiation and Growth of Metal Hydride Corrosion*. LA-UR-00-5496.

Bonded vs. NonBonded Pits

DOE had declassified information about bonded weapon components prior to 1996.[45] A 1998 Technical Risk Assessment of the Plutonium Pit Disassembly and Conversion Facility identified the implications of this distinct design variable when it identified an option with the least technical risk for disassembly and conversion of most plutonium pit types. The *Metal-Only Option* was suggested to process only "nonproblem pits" to produce only a metal plutonium product and no plutonium oxide. This was because "many of the pits, perhaps as many as 80%, can bypass the hydride/dehydride (conversion to metal) module as the plutonium metal can be mechanically separated from the pits."[46]

The pit types where plutonium metal can be mechanically separated using a lathe are called "non-bonded" pits; whereas the pits that require chemical processing–either pyrochemical or liquid–to separate the plutonium in the pit from other pit parts are called "Bonded" pits. In bonded pits, the the plutonium is bonded to other metals in the pit, such as stainless steel, beryllium, and/or uranium..[47] At least one Los Alamos source reports that all Russian plutonium pits are nonbonded.[48]

Bonding and Pit Disassembly and Conversion Issues

To avoid liquid acid "aqueous" processing of pits, Lawrence Livermore National Laboratory developed the ARIES system that included a pit "bisector" for cutting plutonium pits in half (Figure 3-6) -- which suggests that most or all bonded pits are of Livermore design.[49] The bisector is the front end the Advanced Resource Integrated Extraction System (ARIES) that DOE chose as a major part of the pit disassembly and conversion process while it was still in the design and experimental phase.

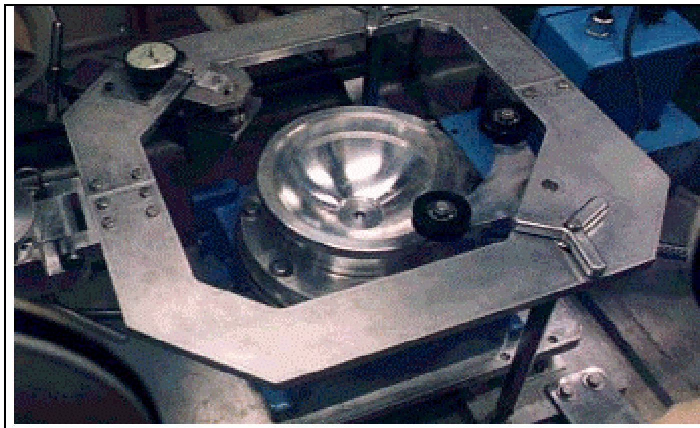

Figure 3-6. Plutonium Pit Bisector.
"The prototype bisector was designed and tested at Livermore. Using a chipless cutting wheel, it can separate weapon pits into two half-shells in less than 30 minutes so that the plutonium in them can be recovered for disposition." *Science and Technology Review*. April 1997. Lawrence Livermore National Laboratory.

Following the pit bisection, the plutonium must the be chemically separated from the pit cladding and other pit parts. The two experimental technologies proposed are hydride-dehydride, which recasts the plutonium as a metal, and HYDOX, which utilizes the reaction of plutonium with hydrogen to produce a plutonium oxide powder.

Do Bonded Pits Lack Tritium?

It is evident that bonded pits are "problem pits" since the metals-only option would defer processing these pits and simplify the plutonium disposition process; although considerable evidence also points to an absence of tritium in bonded pits:

a. Pits containing tritium were not "*selected as part of the ARIES pilot demonstration because of the difficulties associated with handling tritium;"*
b. The original ARIES demonstration line involved only 40 pits and 7 pit types, and the Special Recovery Line was not required for these pit types;
c. The pit bisector in the ARIES process was specially designed to take "into account the dimensions, encapsulation methods, construction materials, and manufacturing techniques of these pits in order to incorporate the representative configurations that will be processed through ARIES." (Gray, 1995. Lawrence Livermore National Laboratory).
d. Chemical processing is unnecessary to separate plutonium from other pit parts in nonbonded pits, so HYDOX was designed for bonded pits as well.

Pit Tubes and Pit Re-Use at Pantex

While DOE pursues plutonium pit fabrication at Los Alamos and possibly SRS, it has abandoned, at least for now, the plutonium pit re-use project planned for Pantex. A pit-re-use project occurred at Pantex in the early 1990's when Rocky Flats was shut down. This project allowed DOE to proceed to complete the W-89 weapon program by re-using W68 pits and converting them to fire-resistant pits by cladding them with vanadium. Heralded then as an innovative approach that avoided messy pit fabrication, the latest plan for pit-re-use went unfunded in fiscal year 2000,[50] and there is no indication that DOE plans to pursue this work, indicating a preference for new pit production at SRS.

One of the sticking points regarding pit-re-use involves pit tubes. Plutonium pit tubes are designed to carry the booster tritium gas from the tritium reservoir to the hollow core of the pit at the time of detonation. According to pit-tube fabrication experts, pit tubes:

- are constructed of annealed type 304 stainless steel that is "very ductile" and able to take severe deformation without cracking or leaking;
- are placed at assembly within tightly fitting slots in the high explosive and must be straight and within true position within 0.02 in 1 inch.
- are usually of 0.12 inch diameter, for pressure testing, evacuation and filling.
- are attached to stainless steel shell by TIG welding or electron beam welding and to beryllium and aluminum shells by high temperature braze[51]

.

Pit re-use was always described as "non-intrusive" during the Environmental Impact Statement process. After Pantex was selected for the pit re-use mission, the mission was renamed "pit requalification" and changed from non-intrusive to intrusive because it included pit tube replacement and refurbishment:

"*SNM Requalification at PANTEX for FY 98 has been as continuation of the original effort and has included an increase in scope to address pre-screening, tube replacement and reacceptance...tube replacement is a capability that was utilized at Rocky Flats. A similar capability is being supported as a part of the Pit Rebuild program at LANL*"[52]

Pit tube replacement was being advocated by Los Alamos prior to the funding cutoff for this program. Because pit tubes are bent to very specific configurations and there is no record of the number of times they have been bent, Los Alamos wanted to replace all pit tubes. However, a LLNL report discussing the stainless steel used in W87 pits reported that the tube would need to be bent at least ten times to pose a great risk of failing (Figure 3-7).[53]

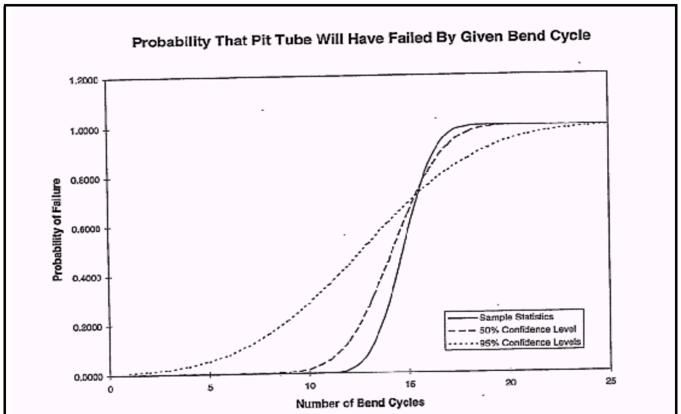

Figure 3-7. Sun-Woo, *Characterization of Stainless Steel 304 Tubing.*

PLUTONIUM STORAGE AT PANTEX: Stockpile Negligence?

Plutonium pits are multimillion dollar weapon components being stored in substandard conditions.

Most pits are stored in the AL-R8 container (Figure 3-11) which is unsuitable for long-term storage. Designed by Dow Chemical in the 1960's. AL-R8's are unsealed and pits stored in them:

- require extra humidity and temperature controls
- are prone to corrosion because the internal celotex packing–sugar cane, paper, starch, and wax--is a source of chlorides and moisture that can lead to corrosion of the pit cladding.
- do not meet all safety criteria–specifically the 1100 pound dynamic crush test.
- provide poor radiation shielding.

There are about 2,000 corroded AL-R8's at Pantex because they were procured without the corrosion resistant liner.

Figure 3-8. AL-R8.

THE AT-400A Fiasco

DOE spent $50,000,000 designing and developing the AT-400-A (Figure 3-9) dual-use shipping and storage container for plutonium pits. Its advantages included:

- a sealed, inert gas environment that would prevent corrosion and other degradation of pits
- better radioactive shielding;
- a 50-year design life.

It's disadvantages included cost ($8,000/unit) and problems associated with the weld–possible burn through of the containment vessel.

DOE estimated that 2,000 plutonium pits per year could be repackaged in the AT-400A, leaving pits in the safest container within a five year period. After the repackaging startup was delayed by more than a year, 20 pits were repackaged in a pilot run before DOE pulled the plug on the entire program. Twenty W-48 pits remain in AT-400A's.

Figure 3-9. AT-400A

The Sealed Insert

DOE replaced the AT-400A with the AL-R8 Sealed Insert (Figure 3-10). It is a significant improvement over the AL-R8 because of the sealed, bolted, stainless steel inner container, but is still not considered worthy of shipping certification. Problems now plaguing this program include[54]:

- a lack of funding to buy new containers at a cost of $2800/unit.
- the need to certify larger "2040-type"AL-R8 sealed inserts for about several pit types ome pits, including most stockpile pits;
- the lack of a pit cleaning station for 1500 pits too dirty for long term storage, so Pantex is having to double-handle some pits;
- a lack of funding for labor, so Pantex is not able to run two shifts;
- a lack of funding for monitoring;
- limited funds for dealing with another cracked pit.
- DOE has only 300 shipping containers called FL's, the certification for the FL's expires in 2002, and more than 200 of these were recently found to not match design drawings;
- DOE has made no reported progress developing a new shipping container (Figure 3-11) to replace the FL and AT-400A.;
- a planned upgrade to Building 12-66 at Pantex was abandoned after the design work was complete, leaving decades-old bunkers as the main storage buildings. (Figure 3-12) These facilities were not supposed to be used after the Year 2000, but will be used indefinitely.

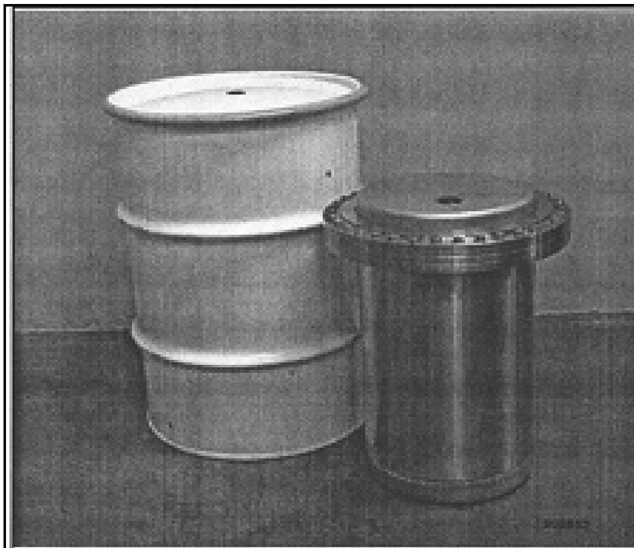

Figure 3-10. AL-R8 with Sealed Insert, 2030 model. There is still a need for 2040 models for several pit types, including national asset pits

?

Figure 3-11. DOE still has no pit shipping container

Figure 3-12. Zone 4 Bunkers at Pantex. Plutonium pits are literally stacked to the ceilings in these WWII and 1960's vintage bunkers. All but a few of these facilities lack required humidity or temperature controls, and are unlikely to withstand an aircraft crash – a serious issue due to the proximity of Amarillo International Airport. Pantex has little space for additional pits.

DOE's Dirty Plutonium Secret
Plutonium Pit Production at Savannah River Site

In the newly downsized U.S. Nuclear Weapons Production Complex, Savannah River Site is the only remaining major plutonium processing site in the country and is in line for three new facilities promoted as "nonproliferation" missions:

a Plutonium Pit Disassembly and Conversion Facility that will process surplus plutonium pits and convert the plutonium in those pits to an unclassified plutonium oxide powder.
b Mixed Oxide (MOX) Fuel Fabrication Facility where "pure" or nearly pure surplus plutonium will be purified using liquid acid processing and then mixed with uranium to make MOX plutonium fuel for nuclear reactors;
c. A Plutonium Immobilization Plant (PIP) where impure and very difficult to purify surplus plutonium will be mixed with uranium and a "titanate" ceramic to make ceramic "pucks." (See below for explanation of can in canister)

Tritium production and recycling is said to be the only nuclear weapons production mission at SRS. However, because Rocky Flats no longer produces nuclear weapons triggers called plutonium pits, new pit production is slated for SRS, and this would inevitably involve the PDCF, making it a dual-use facility:

Plutonium Aging and ARIES as a Weapon Program

In 1998 the Government Accounting Office reported that:

"DOD was concerned that the aging of pits was not clearly identified in our report as a driving force of pit-production requirements. DOD said that it could not give detailed pit-manufacturing requirements until the lifetime of pits is specified more clearly by DOE."

DOE plans to spend over $1.1 billion through fiscal year 2007 to establish a 20-pits-per-year capacity. But this budget does not include disassembly work[55] which is clearly being funded by OFMD under the ARIES development. In addition, plutonium pit enhanced surveillance program, a SSM program, ARIES was identified as a "pertinent task" for the "Pit Focus Program."
material property data from pits dismantled in the ARIES process in order to expand the age-correlated database of applied plutonium properties.[56]

Chairman Spence and the Foster Panel

In 1996 Chairman of the House National Security Committee Floyd Spence (R-South Carolina) issued a report titled "*The Clinton Administration and Stockpile Stewardship: Erosion by Design*," in which he wrote that,"Unprecedented reductions and disruptive reorganizations in the nuclear weapons scientific and industrial base have compromised the ability to maintain a safe and reliable nuclear stockpile...unlike Russia or China, the United States no longer retains the capacity for large-scale plutonium "pit" production and DOE's plans to reconstitute such a capacity may be inadequate."

In December 1999 a congressional panel called the Foster Panel published "*FY 1999 Report of the Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile,"* recommending that DOE:

"*immediately begin the conceptual design phase of a pit production facility adequate to meet national security needs."*[57]

The Chiles Commission

Another vote for pit production was cast by the Chiles Commission, which was established to review the nuclear weapons workforce and determine needs and priorities. The Commission concluded in 1998 report that, "large numbers of workers are reaching retirement and a new generation of workers must be hired and trained in order to preserve essential skills." One of these essential skills is the machining of "materials unique to nuclear weapons," such as plutonium, highly enriched uranium, and beryllium. Their recommendations called for a renewed emphasis on plutonium pit production:

> *"DOE needs to give a much higher priority to detailed planning for the production of replacement weapons components. In the absence of such planning, the sizing of the nuclear weapons workforce at the production facilities is left unnecessarily uncertain*"[58]

The SRS Strategic Plan

The Savannah River Site is very explicit about its potential pit production mission within some documents but does not publicize its intentions in an up-front manner. The *Savannah River Site Strategic Plan: A Strategic Plan for 2000 and Beyond*[59] lists three focus areas for SRS:

- Nuclear Weapons Stockpile Stewardship
- Nuclear Materials Stewardship
- Environmental Stewardship

The plan states that Nuclear Weapons Stockpile Stewardship "emphasizes science-based maintenance of the nuclear weapons stockpile. SRS supports the stockpile by ensuring the safe and reliable recycle, delivery, and management of tritium resources; by contributing to the stockpile surveillance program; and by our ability to assist in the development of alternatives for large-scale pit production capability, if required. associated with products and services essential to achieving the Department of Energy's (DOE) goals."[60] Under Goals, Objectives, and Strategies, the strategic plan states as a goal:

> "*Consolidate existing facilities and plan, design, and construct new facilities to support current and future stockpile requirements*."

Within this goal is the objective to:

> "*Support the development of contingency plans for a new pit production facility to meet future stockpile requirements as national needs emerge*."

Within this objective is the strategy to:

> "*Develop partnerships with the national weapons laboratories and Oak Ridge Y-12 Plant to outline roles for each organization in a large- scale pit manufacturing project.*"

The Los Alamos Perspective

Stephen Younger in 1996 (Los Alamos Science NO. 19).

Stephen Younger, the Associate Laboratory Director for Nuclear Weapons at Los Alamos National Laboratory, which is operated by the University of California under contract to DOE. recently wrote, in *Nuclear Weapons in the Twenty-First Century* that

"Plutonium pit production can be maintained at a small rate at Los Alamos, but any stockpile above about one thousand weapons will require the construction of a new large production plant to replace the Rocky Flats facility, which ceased production in 1989."
"In the case of DOE, an extensive infrastructure of laboratories and plants is required for the Stockpile Stewardship program, including a new manufacturing capability for plutonium pits"

Yet, even under START III conditions, "the U.S. has offered to begin negotiations on ceilings of 2,000 to 2,500 weapons immediately upon Russian ratification of the START II treaty" Obviously, as long as the U.S. intends to maintain more than 1,000 nuclear warheads, then demands for large-scale pit production will be made.

Preparing for Pit Production at SRS?

Several operations at SRS suggest that the site is quietly and surreptitiously implementing its strategic plan as it relates to large-scale plutonium pit production:

1. **Developing Plutonium Casting Capability**. An essential part of plutonium pit fabrication is "casting plutonium metal feed ingots after adding gallium to the plutonium metal and shape-casting the feed ingots into hemishells."

In 1998 SRS developed the capability to recast plutonium metal in the FB-Line "using an M-18 reduction furnace with a new casting chamber." Plutonium metal is recast by charging a standard FB-Line magnesia crucible and placing the charge in the casting chamber. In October 1998, "a *[plutonium] button was produced by combining plutonium and gallium metals to produce an alloy in which the plutonium is stabilized in the d phase. Delta (d) phase metal is not susceptible to low temperature induced phase changes like a phase metal.*"[61]

This effort was portrayed by SRS only as a contingency for plutonium metal storage and not as a dual-purpose program that integrated storage goals with pit production goals:

> *The capability to produce d stabilized metal in FB-Line would provide a contingency for plutonium metal storage at the SRS in the event that experimental programs show that the a to b phase transition (and resulting decrease in density) has the potential to create harmful mechanical stresses in storage containers. The continued use of the casting process for the declassification and consolidation of plutonium from weapons components also provides a disposition path for classified metal parts and alloys currently stored at the RFETS."*[62]

2. Measuring Plutonium Density in Pits. Another capability SRS has developed is a new measurement system for determining plutonium density in finished plutonium pits. The Savannah River Technology Center (SRTC) and Los Alamos undertook a collaborative research project in which SRTC designed, fabricated, and tested a gas pycnometer "to be used to measure densities of surrogate [plutonium pit] parts." The project's objective was to find a more environmentally friendly method for measuring the density of plutonium hemishells in pits.[63]

The plutonium density project is not a dual-use program, and is only necessary for plutonium pit fabrication. Although the project occurred prior to the issuance of the SRS strategic plan, it clearly is an example of collaborating with the national laboratories to define roles for pit production.

3. The Plutonium Pit Disassembly and Conversion Facility. Every analysis of plutonium pit production lists pit disassembly as the first step in the process. For example, a joint paper issued by Lawrence Livermore and Los Alamos National Laboratories specified the first two steps of pit fabrication as:

- dismantlement of the pit;
- conversion of the metal through hydride and oxidize to plutonium oxide (HYDOX) or hydride and reduce to metallic plutonium (HYDEC);[64]

4. The Plutonium MOX Fuel Factory. The capability to purify plutonium for pit fabrication is the missing ingredient in the current version of the PDCF is plutonium purification processing. However, the planned plutonium fuel factory will have the capability to purify plutonium oxide powder.

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stored there.

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29. Glasstone and Redman. *An Introduction to Nuclear Weapons*

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31. Pit Resuse Station. 1993.

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33. Pits are "suspected to be clad with beryllium" in this report if they were separated from the high explosives using similar technologies as the W-48.

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37. Defense Nuclear Facilities Safety Board. *Pantex Plant Activity Report for Week Ending July 10, 1998*.

38.*ARIES Source Term Fact Sheet* (LALP-97-24, Rev. 3, April 24, 1998).

39.http://www.osti.gov/html/osti/opennet/document/rdd-1/drwcrtf3.html#ZZ1

40.SPDEIS. Page 3-923.

41. Los Alamos National Laboratory and Fluor Daniel, Inc. 1997. *Design-Only Conceptual Design Report for the Pit Disassembly and Conversion Facility*. Project No. 99-D-141. Prepared for the DOE Office of Fissile Materials Disposition. December 12, 1997.

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44.Tanksi, John A. 2000. *A Model for the Initiation and Growth of Metal Hydride Corrosion*. LA-UR-00-5496. 23rd DOE Aging, Compatibility, and Stockpile Stewardship Conference. November 14-16, 2000.

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1) Fact that bonding of plutonium or enriched uranium to materials other than themselves is a weapon production process. (93-2)

(2) Fact that such bonding occurs or may occur to specific unclassified tamper, alpha-barrier or fire resistant materials in unspecified pits or weapons. (93-2)

(3) Fact that plutonium and uranium may be bonded to each other in unspecified pits or weapons. (93-2)

(4) Fact that such bonding may be diffusion bonding accomplished in an autoclave or may be accomplished by sputtering. (93-2)

(5) Fact that pit bonding/sputtering is done to ensure a more robust weapon or pit. (93-2) (6) The use of autoclaves in pit production. (93-2)

(7) The fact that plutonium is processed in autoclaves. (93-2)

(8) The fact that sputtering of fissile materials is done at or for any Department of Energy facility as a production process. (93-2)

(9) The fact of a weapons interest in producing a metallurgical bond between beryllium and plutonium. (93-2)

(10) The fact that beryllium and plutonium are bonded together in unspecified pits or weapons. (93-2)

(11) Routine data concerning concentrations of beryllium in plutonium higher than 100 ppm. (93-2)

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49.The list of problem pits, like the list of weapons with disassembly problems, seems to be dominated by LLNL designs. Three of the four pit types requiring cleaning are LLNL designs, as is the most problematic pit, the W-48. The only remaining weapons systems to dismantle under START I are LLNL designs–the W79, the W56, which have both been problematic programs.

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58.Commission on Maintaining United States Nuclear Weapons Expertise. *Report to the Congress and Secretary of Energy* Pursuant to the National Defense Authorization Acts of 1997 and 1998. March 1, 1999

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62.Ibid.

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