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In Brief: U.S. Nuclear Weapon "Pit" Production: Background and Options

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Summary

Congress is involved in the long-running and costly decision regarding the future production of "pits"; a pit is a nuclear weapon's plutonium core. Rocky Flats Plant (CO) mass-produced pits during the Cold War; production ceased in 1989. The Department of Energy (DOE), which maintains U.S. nuclear weapons, then established a small pit manufacturing capability at PF-4, a building at Los Alamos National Laboratory (LANL) (NM). PF-4 has made at most 11 pits per year (ppy). DOE also proposed higher-capacity facilities; none came to fruition.

U.S. policy is to maintain existing nuclear weapons. To do this, the Department of Defense has stated that it needs DOE to have the capacity to produce 50-80 ppy by 2030. This report focuses on options to reach 80 ppy. A separate debate, not discussed here, is the validity of the requirement; a lower capacity would be simpler and less costly to attain.

Pit production requires many tasks, but this report focuses on two: pit fabrication, which forms plutonium into precise shapes, and analytical chemistry (AC), which monitors the composition of each pit. Any feasible option requires sufficient "space" (laboratory floor space) and "Material At Risk" (MAR) allowance. Each building for plutonium work is permitted a specified amount of MAR, i.e., radioactive material (adjusted for radioactivity) that could be released by an event like an earthquake.

Pits can only be fabricated in PF-4. Increasing its capacity to 80 ppy would require making more MAR and more space available in that building, which in turn would require moving out radioactive material and freeing up space. Both could be done, for example, by moving pit casting or work on plutonium-238 (Pu-238), which is much more radioactive than the plutonium used in weapons, out of PF-4.

One pit fabrication option is to build one or more "modules" to move high-MAR work from PF-4. Modules would be reinforced-concrete structures buried near PF-4. Another option is to use buildings at Idaho National Laboratory or Savannah River Site (SRS) (SC); both sites have done work with Pu-238.

Higher capacity also requires more AC, which increases in tandem with capacity. Most AC is not time-sensitive, so some of it could be done at sites other than LANL. PF-4 is not suitable for most AC work. Thus increasing pit production would also require finding one or more sites for AC. AC requires much less MAR and much more space than pit fabrication, so AC options differ from pit fabrication options. Buildings at Lawrence Livermore National Laboratory (CA) and SRS have ample space suitable for AC. LANL would also need a significant AC capacity to support pit production and other work. An option would be to modify the new Radiological Laboratory-Utility-Office Building (RLUOB) so it could handle more plutonium, permitting it to do more AC.

This report shows that many options are available for making 80 ppy, but it cannot determine which, if any, could support that capacity because data do not exist on how much MAR and space are needed for AC and pit fabrication for 80 ppy. Likewise, there are little to no data on cost. However, the report raises questions that Congress may wish to have answered in order to decide how to proceed:

- Is an 80-ppy capacity needed?
- If so, how much space and MAR in PF-4 would fabrication of 80 ppy require?
- Could sufficient space be made available by repurposing PF-4 space? How might enough MAR allowance be made available?
- What are the pros, cons, and costs of Pu-238 options?
- If modules are built, how many would be needed and what would they cost?
- How much space and MAR would AC for 80 ppy require?
- What are the pros, cons, and costs of having SRS or LLNL perform some AC?
- What would it cost to modify RLUOB?

This report summarizes a more detailed report, CRS Report R43406, *U.S. Nuclear Weapon "Pit" Production Options for Congress*, by Jonathan E. Medalia.

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Background

Congress is involved in the long-running and costly decision regarding the future production of "pits"; a pit is the plutonium core of the primary stage of a nuclear weapon. When imploded by high explosives, a pit becomes so compressed that it results in a nuclear explosion that provides the energy to detonate the weapon's main (secondary) stage. During the Cold War, the Rocky Flats Plant (CO) made pits on an industrial scale, sometimes over 1,000 pits per year (ppy). Rocky Flats ceased pit production in 1989. Since then, the United States has made at most 11 ppy despite several failed attempts to build a facility able to produce pits at a higher rate. Yet the Department of Defense (DOD) requires the National Nuclear Security Administration (NNSA), the separately-organized component of the Department of Energy (DOE) in charge of the U.S. nuclear weapons program, to have the capacity to make 50-80 ppy by 2030.[1]

U.S. policy is to "not develop new nuclear warheads … or provide for new military capabilities."[2] However, weapon components age, so life extension programs (LEPs) are underway or planned for each existing weapon type in sequence. Some LEPs will use a weapon's original pit, and other LEPs may use retired pits from other weapon types. Still other LEPs may use newly-manufactured pits, such as to replace original pits that have deteriorated or to incorporate new safety and security features. Some experts argue that additional pit manufacturing capacity is needed to replace pits that encounter problems out of sequence or to hedge against unanticipated geopolitical developments. Others reply that a capacity much less than 80 ppy would suffice. While there is debate over what capacity is needed, this report has a different focus: how to achieve a capacity of 80 ppy. This report summarizes the much more detailed CRS Report R43406, *U.S. Nuclear Weapon "Pit" Production Options for Congress*, by Jonathan E. Medalia.

Pit production involves precisely shaping plutonium, a hazardous, radioactive, physically quirky metal. Production also requires supporting tasks, notably analytical chemistry (AC, defined below). Currently, Los Alamos National Laboratory (LANL) (NM) produces pits at its PF-4 building, and conducts AC and other supporting tasks at its Chemistry and Metallurgy Research (CMR) building.

Several terms are essential for understanding pit production options:

- **Material At Risk (MAR):** DOE defines this term as "the amount of radioactive materials … available to be acted on by a given physical stress."[3] For LANL, earthquakes pose the most severe anticipated physical stress. Each building using radioactive material has a MAR allowance specific to that building.
- **Hazard Category (HC):** A categorization of buildings based on the amount of radioactive material a building is designed to hold. The HC system defines the

[1] Testimony of Andrew Weber, Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, in U.S. Congress. Senate. Committee on Armed Services. Subcommittee on Strategic Forces. *Hearing to Receive Testimony on Nuclear Forces and Policies in Review of the Defense Authorization Request for Fiscal Year 2014 and the Future Years Defense Program*, April 17, 2013, p. 15.

[2] U.S. Department of Defense. *Nuclear Posture Review Report,* April 2010, p. 39.

[3] U.S. Department of Energy. DOE Handbook: *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* Vol. I, Analysis of Experimental Data, DOE-HDBK-3010-94, December 1994, p. xix.

construction type and safety systems needed to keep radiation dose to persons within limits defined by DOE in the event of an accident or building collapse.

- **Radiological Facility:** The lower limit for radioactive material in a building in the HC system is about 26 grams of weapons-grade plutonium (WGPu), which contains mostly plutonium-239 but also other isotopes of plutonium. Buildings with less than this quantity are "Radiological Facilities." They require no special security measures because they have so little material.
- **Security Category (SC):** A categorization of buildings based on the amount and form of radioactive material in a building. The intent of the SC system is to determine what level of security a building needs based on the "attractiveness" of its materials, especially to terrorists. For example, WGPu in metallic form, in quantities sufficient to make a bomb, would be highly attractive, and a building containing large quantities of it requires armed guards, intrusion detection systems, special fencing, and the like. In contrast, WGPu dissolved in a large quantity of acid is much less attractive, so requires much less security.
- **Analytical Chemistry (AC):** AC analyzes many plutonium samples taken from each pit at various stages in its manufacture. AC determines the isotopic composition of WGPu, the amount of other materials added to WGPu, and the amount of impurities. Most AC uses tiny samples, such as a few milligrams of plutonium dissolved in a small amount of acid, so it is low-MAR and low-SC. On the other hand, AC requires a substantial amount of laboratory floor space.
- **Plutonium-238 (Pu-238):** Pu-238 is highly radioactive. Is main use is to power space probes. It bears on pit production options because it occupies 9,600 sf in PF-4 out of 60,000 sf, and accounts for 40 percent of PF-4's MAR allowance.

Pit Fabrication Options

The basis for the following options is that PF-4 is the only U.S. building able to produce pits, as it has high security, a high MAR allowance, and pit production equipment. Increasing its capacity to 80 ppy would entail more production equipment and more MAR. Thus higher capacity requires making MAR and space available. Some space is currently available; more might be as well. Three main tasks contribute to MAR in PF-4: Pu-238 work, pit fabrication, and recovery of plutonium from acid solution. Of these, only Pu-238 may plausibly be moved to another site.

Options Using Modules

One option is to build "modules" at LANL so high-MAR work like processing Pu-238 or casting pits could be moved from PF-4. Preliminary plans envision modules as buried reinforced-concrete structures with 3,000 to 5,000 sf of lab space. Each would be built for a specific task. They would be a few hundred yards from PF-4, and connected to it by a tunnel.

Arguments for modules follow: Since each module would be built for a specific task, each would meet regulatory requirements that apply only to it, rather than having to meet the most stringent regulatory requirements that apply to any work in an entire large building. Modules would draw on many support features offered by that building, such as shipping and receiving, security, temporary waste storage, and a storage vault for nuclear materials. Modules would arguably be faster and less costly to build than the large facilities proposed in the past that were canceled or deferred due to cost growth and schedule slippage. Reducing MAR in PF-4 would extend the life of that building if its MAR allowance were reduced over time as a result of more stringent regulations, problems that emerge in the building, increased calculation of seismic threat, etc.

Arguments against modules follow: Modules would not be needed if high-MAR work could be done in existing buildings, as described below. Even if modules are needed, they are arguably not needed now, as PF-4's service life could be extended. While they could use some of PF-4's infrastructure, they would need much infrastructure of their own, such as for ventilation and fire suppression, as well as special filters to prevent plutonium from escaping into the air in the event of an accident. Modules might cost billions of dollars because they would be high-HC and, for pit casting, high-SC as well. NNSA's cost estimation for major weapons and facilities projects has fallen short in the past; could Congress have confidence in cost estimates for modules?

Options Using Existing Buildings

Another approach is to use existing buildings. Most of the nuclear weapons complex was built during the Cold War and was sized to produce, at times, over 1,000 weapons per year. Thus existing buildings in the complex have much unused space, some of which is suitable for high-MAR work. These buildings might require modifications.

At least two sites could house the Pu-238 mission. Idaho National Laboratory (INL) and Savannah River Site (SRS) (SC) have both done work with Pu-238. Both have buildings that could be used for this purpose, Building CPP-1634 at INL and H Canyon and HB-Line at SRS. DOE prepared a study in 2013 on these options and found that both sites could be used for this purpose, at a cost between $122 million and $272 million.[4] This cost estimate is preliminary.

Analytical Chemistry Options

There are two sources of demand for AC capacity. CMR, most of which was built in 1952, does most AC for pit production, but is scheduled to halt operations around 2019; its work would have to be moved elsewhere. Higher capacity also requires more AC, as the two increase in tandem. PF-4 is not suitable for most AC work. Thus increased pit production would also require finding one or more sites for AC.

Options at Sites Other Than Los Alamos

Several approaches could provide AC space. Some AC could be done at a site other than LANL, as most AC is confirmatory rather than time-urgent, allowing some leeway in when samples are analyzed. During the Cold War, SRS produced WGPu for as much as several hundred ppy. All this plutonium required AC, and SRS has two facilities, F/H Laboratory and Building 773-A, that conducted AC and remain suitable for AC. Each has enough space for AC for 80 ppy.

[4] U.S. Department of Energy. Space and Defense Power Systems. Radioisotope Heat Source Infrastructure Review Team. "Evaluation of Radioisotope Fuel Processing and Heat Source Fabrication Infrastructure Capabilities, Final Report," May 2013, p. 4-4.

Building 332 at Lawrence Livermore National Laboratory (LLNL) used to have the same HC and SC as PF-4, and formerly handled large quantities of WGPu, such as to build nuclear explosive devices for testing. However, NNSA directed LLNL to remove almost all the plutonium from this building to lower its Security Category. This work was completed in 2012. This action greatly reduced the security cost and the amount of weapons-usable material potentially vulnerable to theft. However, the building has ample space and other attributes suitable for AC work, and could handle AC for 80 ppy. Both SRS and LLNL could handle the MAR associated with AC in support of producing 80 ppy, though shipment of samples to LLNL would have to be staggered to avoid breaching its MAR limit.

Options at Los Alamos

Analysts have argued that it would not be desirable to perform all AC at a site other than LANL. All plutonium work requires AC. LANL, as the "center of excellence" for plutonium, requires AC, and would need a significant AC capacity for pit production, such as for quick-turnaround analyses, for solving problems, for maintaining expertise and equipment, and for training. On the other hand, it may be desirable to have one or perhaps two other sites perform AC to support pit production to distribute expertise, to cross-check AC at LANL, to accommodate a surge in demand, and to have a backup in case of problems with AC facilities at LANL.

PF-4 performs some AC, and could perform somewhat more. However, it is unsuitable for large-scale AC because most AC is best done in open-front hoods, which require a massive ventilation capacity to draw air into the hoods in order to keep acid and plutonium from contaminating lab rooms. It would be very costly, if not impossible, to retrofit that capacity into PF-4. Besides, low-MAR activities like AC are an inefficient use of the valuable high-MAR space at PF-4. Another possibility is to use an existing building at LANL, the Radiological Laboratory-Utility-Office Building (RLUOB, pronounced rulob). RLUOB was completed in FY2010 has 19,500 sf of laboratory space, and has a massive ventilation system. There are three possibilities.

- Use RLUOB for AC with 26 grams of WGPu. Since it is a Radiological Facility, that is the most it can hold under existing regulations. Twenty-six grams is enough to perform a substantial amount of AC because many AC samples are a few milligrams of plutonium dissolved in a small amount of acid. However, 26 grams of plutonium—the volume of two nickels—is nowhere near enough for large-scale AC. LANL has not studied how much plutonium the AC for 80 ppy would require, but it estimates the figure is on the order of 500 to 1,000 grams. Similarly, LANL has not studied in detail how much floor space the AC for 80 ppy would require, but estimates that if all laboratory space in RLUOB could be used with 500-1,000 grams of plutonium and if some additional space could be made available for AC in PF-4, that might suffice.
- Convert RLUOB from a Radiological Facility to an HC-3 building, which would permit it to hold 1,750 grams of WGPu. LANL estimated that this conversion would cost between $15 million and $50 million.[5] This cost estimate is preliminary and would require further study and validation.

[5] Leasure, C. L., M. M. Nuckols, et al., "Los Alamos Initial Response for Maintaining Capabilities with Deferral of the CMRR Nuclear Facility Project," Los Alamos National Laboratory, LA-CP-12-00470 (UCNI), April 16, 2012. The study is categorized as unclassified controlled nuclear information, so is not available for use in this report.

- Create an exemption for RLUOB to hold HC-3 quantities of plutonium without being converted to HC-3. This approach would probably permit NNSA to halt work in CMR by 2019, removing workers and plutonium from a building that is much more at risk of collapse from an earthquake than is RLUOB. While RLUOB is not HC-3, LANL calculated that the radiation dose resulting if RLUOB, with 1,000 grams of WGPu, collapsed in an earthquake would be far below the standard set by DOE. On the other hand, some would object to modifying regulations, especially for buildings housing radioactive material.

Questions for Congress

This report shows that many options could address DOD's requirement for 80 ppy, but it cannot determine which, if any, could meet this requirement because data do not exist on how much MAR and space are needed for AC and pit fabrication for 80 ppy. Likewise, there are little to no data on cost. However, this report raises questions that Congress may wish to have answered in order to decide how to proceed. Questions include:

- Is an 80-ppy capacity needed?
- If so, how much space and MAR in PF-4 would fabrication of 80 ppy require?
- Could that amount of space be made available by repurposing PF-4 space? If not, what changes would be needed? How could enough MAR allowance be made available? What would be the cost?
- What are the pros, cons, and costs of Pu-238 options?
- Are modules needed, or are other options preferable?
- The FY2014 National Defense Authorization Act permits NNSA, once certain conditions have been met, to build two modules. One module of 5,000 sf could take on most of the Pu-238 MAR from PF-4 and would free up about 5,000 sf in that building. Would the additional freed-up MAR and space permit PF-4 to fabricate 80 ppy? If so, would there be a need for a second module? What would be the cost of the first module? Would a second module cost less?
- How much space and MAR would AC for 80 ppy require?
- What are the pros, cons, and costs of having SRS or LLNL perform some AC?
- What would it cost to convert RLUOB to HC-3? What would be the adverse consequences if RLUOB were operated as is with 1,000 g of WGPu?

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