Pit production in the United States: Background and issues

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22 February 2018

The fissile core of the first explosive stage (the "primary") of every thermonuclear warhead and bomb is an assembly of symmetric, concentric shells and supporting parts called a "pit." The typical US pit is composed of about 25 parts.[1] The two innermost hemishells (subsequently welded together and plated), are made of an alloy of plutonium-239.[2]

U.S. Pit Production History

From 1965 to 1989, the Rocky Flats Plant near Denver was the sole U.S. manufacturing plant for pits.[3] On June 6, 1989 the plant was raided by the EPA and FBI as a result of its environmental crimes, extensive contamination, and severe abuses of worker health. Pit production never restarted there.

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[1] LANL interview with Richard Mah, who later became Associate LANL Director for Weapons, Engineering and Manufacturing, in LANL, "Nuclear Facilities Master Plan for Stockpile Stewardship and Management Support," July 1996. Mah said that LANL's Sigma Complex buildings, which are not plutonium facilities, normally produce 22 out of 25 of the parts in a typical pit; what is missing after counting the two plutonium hemi-shells is the pit tube, to convey boost gas into the center of the pit, which is made of commercial stainless steel tubing.

[2] The main (or possibly only) fissile material in current US pits is weapons-grade Pu (WgPu; ~94% Pu-239), or for some primaries, "supergrade" Pu (~98% Pu-239) (Carson Mark, "Explosive Properties of Reactor-Grade Plutonium," 1993 and 2009, *Science & Global Security*, 4(1), 1993, http://scienceandglobalsecurity.org/archive/sgs17mark.pdf). Since the Manhattan Project, plutonium in pits has been alloyed with a small amount of gallium to stabilize it in the delta crystalline phase, resulting in a ductile, copper-like material. This has been the preferred main fissile material for pits in modern warheads because of its relatively small critical mass, high energy density and therefore great X-ray production, stable metallurgical properties and machinability, and relative availability. U-235 has been used and might be present in some pits, but uranium presents orders of magnitude fewer health challenges than plutonium and so, if present at all in the "enduring" stockpile, it is much less of a manufacturing and infrastructure issue. Beryllium shells are present in many (perhaps all) pits. Although very dangerous in finely-divided forms, beryllium is prepared and fabricated with relative ease commercially and in the US warhead program compared to plutonium.

[3] DOE, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences*, 1997, Chapter 2; at http://legacystory.apps.em.doe.gov/text/link/linktoc.htm. There is some indication that LANL's Technical Area (TA-) 21 site may have briefly resumed quantity pit production (which it had done up to 1949) in the immediate aftermath of the disastrous 1969 Rocky Flats fire (Ken Silver, personal communication). In 1978, the plutonium facilities at TA-21 were replaced by those at TA-55, principally at PF-4, and eventually those at TA-21 were fully demolished.

Today, 29 years since Rocky Flats ceased production, the US has no functioning factory for pits despite perennial claims that having such a factory is of signal importance to the US nuclear warhead enterprise and the overall US nuclear deterrent.

While there is some pit production capability at Los Alamos National Laboratory (LANL), centered in LANL's main plutonium facility (Building PF-4 in TA-55), that capability has been unreliable. Since 2013 it has been dogged with persistent safety problems and has operated only sporadically, partly for lack of mission need and partly for serious safety deficiencies, especially in criticality safety. The saga of safety issues at PF-4—and of the pit production claims and promises not met there in the post-Cold War period—is long and must be left for another time.

PF-4 was built in 1978 to standards that have long been superseded, for research and prototyping, not sustained production. It has been the continuing object of hundreds of millions of dollars in structural and mechanical renovation. NNSA estimates PF-4's end-of-life at 2039.[4] No one really knows when accumulating problems will increase downtime and risks beyond acceptable levels.

Pit Production Requirements and Pit Aging

NNSA's current program of record, the FY 2018 Stockpile Stewardship and Management Plan, requires "50–80" ppy production by 2030.[5] Somewhat more stringently, the pit production Assessment of Alternatives (AoA), issued the same month as this requirement, refers to a "sustained production capacity of *no fewer than 80* ppy by 2030", and this "at high confidence" (emphasis added).[6]

Every Stockpile Stewardship and Management Plan since FY15 has used the "50–80 by 2030" formulation.[7] The FY14 Stockpile Stewardship and Management Plan (released June 2013) was more tentative, saying "*Preliminary* plans call for pit

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[4] DOE, FY 2014 Congressional Budget Request, Vol. 1 (NNSA), April 2013, p. WA-211. http://www.lasg.org/budget/FY2014/Volume1.pdf.

[5] See NNSA/DOE, FY 2018 Stockpile Stewardship and Management Plan (SSMP), Nov 2017, p. 2-30. We do not know, at this time, if there is any technical basis for moving the first year of "50–80" ppy production forward 1 year from the "2031" of the early 2014 Hagel report above to the late 2017 SSMP's "2030," but the latter date is by now traditional. See also further references at http://www.lasg.org/budget/NNSA_Planning_Budgeting.html.

[6] "Plutonium Pit Production Analysis of Alternatives (AoA) Results and Next Steps," NNSA, November 2017, Slide 3, http://www.lasg.org/MPF2/documents/PlutoniumPitProductionAoA_Nov2017_9pg.pdf.

[7] Fiscal Year 2015 Stockpile Stewardship and Management Plan, http://www.lasg.org/documents/SSMP-FY2015_10Apr2014.pdf.

production of *potentially up to* 80 [ppy] starting *as early as* 2030" (emphasis added).[8] Prior Stockpile Stewardship and Management Plans in April 2011 and May 2010 called for a pit production capacity of 80 ppy to be in place at LANL by 2022.[9]

NNSA's 80 ppy requirement is said to derive from "pit aging estimates and planned production schedules to meet military requirements."[10] Pits do age. Eventually a pit must be replaced, or retired. We do not know how long specific kinds of pits are projected to last, with or without compensating measures to increase primary performance margins, and with or without partial rebuilding to replace external parts if needed.

In 1997, the DOE launched a comprehensive study of pit aging at both LANL and Lawrence Livermore National Laboratory (LLNL), building on surveillance and analysis that had been going on for many decades at these labs. A 2006 JASON review of these studies found, in the words of NNSA Administrator Brooks' cover letter to the Senate Armed Services Committee, that

> …most plutonium pit types have credible lifetimes of at least 100 years. Other pit types have mitigation strategies either proposed or being implemented. Overall, the studies showed that the majority of plutonium pits for most nuclear weapons types have minimum lifetimes of at least 85 years.[11]

In 2008, the Department of Energy (DOE) and the Department of Defense (DoD) wrote that "depending on warhead type, the best estimate of *minimum* pit life is 85-100 years" (emphasis added).[12] By 2012, artificially-aged plutonium samples at LLNL had reached a simulated 150 years of age without displaying weapons-

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[8] Fiscal Year 2014 Stockpile Stewardship and Management Plan, http://www.lasg.org/documents/SSMP-FY2014.pdf.

[9] Fiscal Year 2012 Stockpile Stewardship and Management Plan, http://www.lasg.org/documents/SSMP-FY2012.pdf; FY 2011 Biennial Plan and Budget Assessment on the Modernization and Refurbishment of the Nuclear Security Complex, http://www.lasg.org/budget/Sect1251_FY2011_BiennialPlan_BudgetAssmt_AnnexD_May2010.PDF.

[10] NNSA pit production AoA, Slide 3.

[11] Letter from NNSA Administrator Linton Brooks to Senator Warner, November 28, 2006, attached to Hemley, R. J., et. al. "Pit Lifetime," JSR: 06-335, The MITRE Corporation, Nov 28, 2006, http://www.lasg.org/JASONs_report_pit_aging_ocr.pdf.

[12] DOE and DoD, "National Security and Nuclear Weapons in the 21st Century," Sept. 2008, p. 21ff. https://www.defense.gov/Portals/1/Documents/pubs/nuclearweaponspolicy.pdf.

significant aging effects via the two phenomena which had been of greatest concern (phase stability and void swelling).[13]

In a letter to congressional committees following the LLNL article, LANL wrote, "[p]it production to replace pits in the deployed stockpile due to plutonium aging is not required, nor is it planned to occur."[14] What aging phenomena involving the plutonium components in pits are relevant then, if any, and on what time scale? If plutonium aging per se is not an issue, that still leaves issues related to welding, plating, and corrosion, the pit tube, and any plutonium- or plating-related issues related to the mechanical support of the innermost (plutonium) shell. All issues affecting the more superficial (non-nuclear) components of pits can be resolved by replacing those components, without rebuilding the plutonium components and without having to do the work in a plutonium-handling facility.

The publication of integrated, open data on pit aging has since gone "dark." At the moment, we know of no new data which would shorten (or lengthen) the "credible" (2006, JASON) and "best" (2008, DOE and DoD) minimum pit lifetimes in the range of 85 to 100 years. *Average* or *median* pit lifetimes may be much longer than this *minimum* life of 85 to 100 years.

The following exchange took place between Senator Feinstein and NNSA Administration D'Agostino on March 21, 2012:[15]

> SEN. FEINSTEIN: Let's talk a little bit about pit production. In 2007 [sic – 2006] the JASONs found that the plutonium in pits can last up to 100 years without affecting nuclear weapons' performance. And recent assessments, I'm led to believe, may indicate that pit lifetimes may even approach 200 years. Has NNSA conducted pit aging studies in the last five years?

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[13] Heller, Arnie and Chung, Brandon, "Plutonium at 150 years: Going Strong and Aging Gracefully," *Science &Technology Review*, Lawrence Livermore Nuclear Laboratory, Dec 2012, https://str.llnl.gov/Dec12/pdfs/12.12.2.pdf.

[14] LANL talking points re: LASG's "Plutonium in Warhead Cores ("Pits") Stable to 150 Years," Dec 6, 2012, http://www.lasg.org/documents/PF_documents/LANL_comments_LASG_paper_6Dec2012.html. See also Los Alamos Study Group comments on these LANL talking points, Dec 12, 2012, http://www.lasg.org/LASG_comments_LANS_ltr_12Dec2012.html. The Los Alamos Study Group press release that prompted LANL's comments is "Plutonium in Warhead Cores ("Pits") Stable to 150 Years, Dec 6, 2012, http://www.lasg.org/press/2012/press_release_6Dec2012.html.

[15] Energy And Water Development Appropriations For Fiscal Year 2013, U.S. Senate, Subcommittee Of The Committee On Appropriations, Wednesday, March 21, 2012, pp.35-36, https://www.appropriations.senate.gov/imo/media/doc/hearings/03_21_12%20E&W%20NNSA%20Budget%20GPO%20Record.pdf

MR. D'AGOSTINO: Madam Chairman, the – we are continuing –

SEN. FEINSTEIN: Yes or no.

MR. D'AGOSTINO: Yes.

SEN. FEINSTEIN: OK –

MR. D'AGOSTINO: And I'm not familiar with the 200-year estimate that you provided, but the original 100 years calculation that we did and the JASONs did validate it, as you suggest.

SEN. FEINSTEIN: And could we please see the results of your pit aging studies in the last five years?

MR. D'AGOSTINO: Yes, ma'am. Yeah, it's continuous. Yes, of course.

SEN. FEINSTEIN: OK. I'd like to see it.

We are unaware at this time if these results were ever provided to Congress.