

# INTRODUCTION

In 1993, UK Foreign Minister Lady Chalker, attempting to reassure the British House of Lords regarding concerns that British commercial reprocessing activities would lead it to export plutonium to nonnuclear weapon states, said that reactor-grade plutonium was “not suitable” for nuclear weapons.<sup>1</sup> However, ten days later the British Foreign Office had to retract this statement, saying that Lady Chalker had been “improvising.”

In fact, the United States had revealed in 1976 that the plutonium produced by nuclear power reactors, “reactor-grade plutonium,” can be used even in the most primitive nuclear weapon design to produce powerful nuclear explosives. From the above incident, it is clear that the UK concurs with the U.S. assessment. Indeed, it is known but not widely recognized that both Pakistan and Sweden at one time based their nuclear weapons programs on reactor-grade plutonium and India may be using reactor-grade plutonium in some of its nuclear weapons today.

Yet many in the nuclear industry continue to claim, as Lady Chalker did, that reactor-grade plutonium is not suitable for nuclear weapons. Using a term originally used for alcohol, they sometimes say that plutonium can be “denatured.” These claims are usually based on two properties of reactor-grade plutonium—its high spon-

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1. Geoffrey Lean, “DIY Atom Bomb Link to Sellafield,” *The Observer*, June 6, 1993, p. 3.

taneous fission neutron production rate which could lead a weapon to predetonate, reducing its yield and, for reactor-grade plutonium which is produced by high burnup in light-water reactors (LWRs), its high decay heat which could potentially pose a threat to a weapon's operability.

There are generally two variants of the view that reactor-grade plutonium is denatured. In the first view, reactor-grade plutonium is truly denatured and it is impossible for simple fission nuclear weapons to be manufactured from it. This view is usually applied to reactor-grade plutonium that is produced in LWRs and is attributed to the high heat of this plutonium. For example, Gunter Kessler, a retired nuclear scientist from the Karlsruhe Nuclear Research Center in Germany, has published a lengthy book on this subject. He says, "Limits were worked out above which the share of Pu-238 isotopes [sic] in plutonium renders the use in nuclear explosives technically impossible (proliferation proof)."<sup>2</sup>

In the second view, the proponents will admit that some sort of simple fission nuclear explosive can be produced from reactor-grade plutonium. However, in this view, this is only a technicality as the plutonium is seen as being de facto denatured. Due to the predetonation probability resulting from the high Pu-240 content, such weapons are often seen as "unreliable and unpredictable" as well as somehow being "hazardous" to the bomb makers.<sup>3</sup> Therefore, no country would actually use reactor-grade plutonium to produce a nuclear arsenal.

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2. G. Kessler, *Proliferation-Proof Uranium/Plutonium Fuel Cycles: Safeguards and Non-Proliferation*, KIT Scientific Publishing, 2011, preface, page unnumbered but page ten of the PDF file, available from <https://www.ksp.kit.edu/9783866446144>.

3. World Nuclear Association, "Plutonium," updated March 2017, available from <http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/plutonium.aspx>.

Sometimes the threat from the plutonium's radiation or the need to cool its core is mentioned as well. For example, Japan's Council for Nuclear Fuel Cycle has said, "If you are lavish of time and money, you will probably be able to build 'devices' that induce nuclear explosions even with reactor-grade plutonium; however, such devices will likely to be bulky ones equipped with secure radiation protection and cooling devices that are rarely found in general nuclear weapons."<sup>4</sup>

A related argument is the claim that no country has ever used reactor-grade plutonium to produce a nuclear explosion. Since the U.S. use of reactor-grade plutonium in a 1962 nuclear test contradicts this argument, many have incorrectly claimed that this test did not actually use reactor-grade plutonium.

Remarkably, officials in the prior U.S. administration, including President Obama himself, have used some of these mistaken beliefs as a basis for a portion of the July 2015 Iran nuclear deal (the Joint Comprehensive Plan of Action). The deal contains a provision that restricts Iran's Arak nuclear reactor from producing weapon-grade plutonium in normal operation. The nuclear deal intends for the reactor to produce fuel-grade plutonium instead (for the definition of the different grades of plutonium, see chapter three). President Obama in defending the Iran nuclear deal has claimed that weapon-grade plutonium is necessary to produce a nuclear weapon, even though it is well-known that fuel-grade plutonium can be used to produce nuclear weapons—something that even the nuclear industry does not dispute.<sup>5</sup> Though parts of the U.S. Department

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4. "No More Innocent Logic "Plutonium Equals to Nuclear Weapons,"" *Plutonium*, Spring 2016, no. 84, p. 2.

5. For example, he has said: "Because of this deal, Iran will not produce the highly enriched uranium and weapons-grade plutonium that form the raw materials *necessary* for a nuclear bomb." [Emphasis added] "Read President Obama's Remarks on Iran Nuclear Deal," *Time*, July 14, 2015.

of Energy know that the President's statements are false, they have apparently decided to stay silent so as to not contradict the boss.

I was part of the research team at Pan Heuristics led by Albert Wohlstetter that in 1976 forced the U.S. government to publicly acknowledge for the first time the nuclear weapon dangers of reactor-grade plutonium. In 1977, the U.S. government went further and revealed that in 1962, it had successfully tested a nuclear weapon using reactor-grade plutonium. In 2013, I refuted the nuclear industry's claim that this test did not use reactor-grade.<sup>6</sup>

Certainly if one has the choice to produce nuclear weapons using either weapon-grade plutonium or reactor-grade plutonium, one would always choose weapon-grade plutonium. However, in countries such as Japan where plutonium is recycled as power reactor fuel, there is ready access to reactor-grade plutonium either in separated form or as unirradiated MOX fuel from which the plutonium can be easily separated. Weapon-grade plutonium may not be so easily available. Then the choice is not between reactor-grade plutonium and weapon-grade plutonium but rather between reactor-grade plutonium and no nuclear weapons at all. At one time in their nuclear weapon programs, both Sweden and Pakistan made this latter choice though for various reasons neither country would eventually produce nuclear weapons from reactor-grade plutonium. India may be using reactor-grade plutonium in its nuclear weapons program today.

Further, though some have argued that countries would never use an inferior nuclear material in nuclear weapons, it should be remembered that weapon-grade plutonium is an inferior nuclear material

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6. Gregory S. Jones, "What Was the Pu-240 Content of the Plutonium Used in the U.S. 1962 Nuclear Test of Reactor-Grade Plutonium?" May 6, 2013, available from <http://nuclearpolicy101.org/wp-content/uploads/2013/05/Reactor-grade-plutonium.pdf>. See also chapter eight.

when compared to pure Pu-239. However, it is not easy to produce large quantities of this latter material and countries have found a way to make do with weapon-grade plutonium. Tens of thousands of nuclear weapons have been produced from this “inferior” nuclear material. Similarly, as will be shown in this book, it is possible to make do with reactor-grade plutonium and produce powerful nuclear weapons with a predetonation probability no higher than that of weapons manufactured using weapon-grade plutonium.

One reason why the nuclear weapons potential of reactor-grade plutonium has not been fully appreciated is that discussions focus only on nuclear weapons of the Nagasaki design. But this is completely unrealistic. No country today would use such a design as its first nuclear weapon. It is well known that the performance of unboosted fission weapons can be significantly improved by using levitation, i.e. putting an air gap into the weapon to increase the efficiency of the implosion weapon. As will be seen in chapter four, such technology can improve the assembly speed by up to a factor of three. The United States used such weapons in the early 1950’s and even over 50 years ago, France and China used such weapons in their first nuclear tests.

In this book, I will show that reliable nuclear weapons can be manufactured using reactor-grade plutonium. Using early 1950s U.S. unboosted levitated fission weapon technology and modern high explosives, nuclear weapons can be manufactured with a predetonation probability no higher than that of weapon-grade plutonium by using the simple expedient of reducing the amount of plutonium used in the weapon. These weapons would be exactly the same size and weight as weapons using weapon-grade plutonium. The yield of such weapons would be about 5 kilotons and their lethal area about 40% of that of nominal 20 kiloton weapons.

Reducing the amount of plutonium in the weapon also makes the higher heat output of reactor-grade plutonium produced in LWRs

manageable as does the fact that the plutonium core can be kept separate from the weapon until shortly before use. The core would require no special cooling. Coating the plutonium core with just one half centimeter of uranium reduces the gamma radiation to significantly less than that from an unshielded weapon-grade plutonium core. Boosting technology, which is becoming more widely available, allows reactor-grade plutonium to be used in nuclear weapons to produce the same yield as weapon-grade plutonium without any risk of predetonation.

Chapter one looks at the issue of how the much easier access to reactor-grade plutonium provided by commercial nuclear power might lead a country to prefer to use this material to produce nuclear weapons. Chapter two provides a short history of reactor-grade plutonium and shows that the nuclear industry's desire to recycle plutonium has led it to downplay the dangers of reactor-grade plutonium. Chapter three provides some of the basic properties of plutonium, how it is classified into different grades, and how plutonium's properties can vary depending on the initial enrichment and burnup of the reactor fuel that produces the plutonium. Chapter four discusses how the spontaneous fission of plutonium can affect the probability of a weapon predetonating and shows that the predetonation probability of a weapon using reactor-grade plutonium can be made equal to that of a weapon using weapon-grade plutonium. Chapter five discusses how the decay heat of reactor-grade plutonium might affect the functioning of a nuclear weapon and shows that reactor-grade plutonium produced by high burnup in current LWRs, by MOX fuel or recycled uranium, can be effectively used in fission weapons using the U.S. early 1950s level of technology including a levitated design and modern high explosives. Chapter six discusses the additional radiation from reactor-grade plutonium and shows that this weak radiation is easily shielded against. The chapter also looks at the critical mass of reactor-grade plutonium and shows that it is always significantly less than that of highly enriched uranium

(HEU). Chapter seven examines the role that reactor-grade plutonium played in the nuclear weapon programs of Sweden and Pakistan and may be currently playing the nuclear weapon program of India. Chapter eight shows that the 1962 U.S. nuclear test of reactor-grade plutonium used plutonium that was 20% to 23% Pu-240. It also shows that the British 1953 Totem test series did not use non-weapon-grade plutonium and therefore these tests provide no information on the usability of such plutonium in nuclear weapons. Chapter nine summarizes my conclusions. The appendix provides a history of the Pu-240 content of U.S. weapon-grade plutonium and provides key information on the Pu-240 content of the plutonium that the U.S. used to manufacture unboosted fission nuclear weapons in the late 1940s and early 1950s.