

## What is the Minimum Enrichment of Weapon-Grade Highly Enriched Uranium?

On February 28, 2023, the International Atomic Energy Agency reported that uranium particles found at Iran's Fordow uranium enrichment plant had an enrichment of 83.7%. Multiple media sources stated that this enrichment was close to the 90% enrichment required for weapon-grade uranium. However, these media statements were not correct, as based on historical experience, it is known that highly enriched uranium (HEU) with an enrichment as low as 80% is weapon-grade.

Judging from published critical mass data, the U.S. appears to have used HEU with an enrichment of between 93% and 94% for its nuclear weapons.<sup>2</sup> Other countries have used HEU with a 90% enrichment, China being one example.<sup>3</sup> Over the years, the belief that weapon-grade HEU needed to have an enrichment of at least 90% has become widespread.

However, it is known that HEU enriched to less than 90% can be used to produce nuclear weapons. The most prominent example is that of the U.S. nuclear weapon that was dropped on Hiroshima. An approximate curve of the HEU produced during the Manhattan Project, published in the 1960s, showed that the Hiroshima weapon contained about 50 kilograms of U-235 in uranium that was enriched somewhere between 63% and 89%<sup>4</sup>. Coster-Mullen has published more detailed information regarding the production of the HEU for the Hiroshima weapon.<sup>5</sup> From this information I was able to determine that the weapon contained about 52.9 kilograms of U-235 in uranium that was about 82.5% enriched.<sup>6</sup>

Nor is 82.5% the lower limit for weapon-grade HEU. The South Africans had a nuclear weapon program based on HEU. Initially its indigenously developed uranium enrichment plant (the Y plant) was unable to enrich to levels higher than 80%. As a result, when South Africa assembled its first nuclear weapon in November 1979, it contained about 45 kilograms of U-235 in uranium

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<sup>1</sup> This paper is the product of the author's personal research and the analysis and views contained in it are solely his responsibility. Though the author is also a part-time adjunct staff member at the RAND Corporation, this paper is not related to any RAND project and therefore RAND should not be mentioned in relation to this paper. I can be reached at [GregJones@proliferationmatters.com](mailto:GregJones@proliferationmatters.com)

<sup>2</sup> H. C. Paxton, "Los Alamos Critical Mass Data," LAMS-3067, Los Alamos Scientific Laboratory, May 6, 1964, p. 11.

<sup>3</sup> John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988, p. 136.

<sup>4</sup> David Hawkins, "Manhattan District History, Project Y, The Los Alamos Project," Volume I, Inception Until August 1945, LAMS-2532, written 1946, distributed December 1, 1961, p. 308.

<sup>5</sup> John Coster-Mullen, *Atom Bombs, The Top Secret Inside Story of Little Boy and Fat Man*, 2009, p. 266. This production data was originally published in the Oak Ridge document: A.L. Compare and W.L. Griffith, "The U.S. Calutron Program for Uranium Enrichment: History, Technology, Operations and Production," ORNL-5928, October 1991. This production data was provided to Coster-Mullen by Dr. Robert Norris of the Federation of American Scientists.

<sup>6</sup> Gregory S. Jones, "Fissile Material Conversion Times, Wastage and Significant Quantities: Lessons from the Manhattan Project," December 16, 2015, p. 6.  
<https://nebula.wsimg.com/d3cd819efec4dd9537d29075dfff524a?AccessKeyId=40C80D0B51471CD86975&disposition=0&alloworigin=1>

that was about 80% enriched.<sup>7</sup> The weapon used a gun-type design and the South Africans estimated that the weapon would have had a yield of about 6 kilotons.

It is likely that nuclear weapons could be manufactured using HEU with an enrichment even lower than 80%. However, there are no examples of any country using such HEU to produce a nuclear weapon. Therefore, I think that based on current information, HEU with an enrichment of 80% provides a robust definition of the lower limit for weapon-grade uranium. The 83.7% enriched HEU produced by Iran is certainly weapon-grade.

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<sup>7</sup> David Albright with Andrea Stricker, *Revisiting South Africa's Nuclear Weapons Program*," Institute for Science and International Security, 2016. <https://isis-online.org/uploads/isis-reports/documents/RevisitingSouthAfricasNuclearWeaponsProgram.pdf>