PREFACE

This book addresses the issues associated with the production of reactor-grade plutonium in nuclear power reactors, which are used to generate electricity. Properties of reactor-grade plutonium, which are critical in assessing nuclear proliferation risks, are analyzed.

Plutonium is the first "man-made" chemical element (its atomic number in the periodic table of elements is 94), which does not occur in nature and which, however, has been produced by the mankind. For this purpose, a unique facility – a nuclear reactor – has been developed, the first prototype of which was launched in December 1942. Soon after that the United States started large-scale production of weapon-grade plutonium, and in July 1945 the fact of nuclear weapons development was broadcasted with the first nuclear explosion in the Alamogordo Desert. Following this, the USSR, Great Britain, France and China entered the nuclear arms race. The nuclear weapon stockpiles of these five countries use plutonium as a major material. Of the four "unofficial" nuclear armed states, India, Israel and North Korea acquired the nuclear-weapons status through plutonium production. Although Pakistan initially relied on highly enriched uranium, it has substantially increased weapons-related plutonium production since then. Thus, plutonium is a byword for the material essence of nuclear weapons.

As nuclear reactors generate large quantities of energy during their operation, it was recognized at the dawn of nuclear age in the 1940s that this energy can also be utilized for peaceful purposes – primarily, for the production of electricity. This instigated the process of conversion of nuclear reactors from producers of weapon-grade material into producers of electricity. A lot of designs and modifications of nuclear power reactors have been developed, and peaceful nuclear programs have grown with time to exceed those aimed at nuclear weapons development.

All nuclear power reactors produce plutonium, which is called reactor-grade plutonium as distinct from weapon-grade plutonium produced by dedicated plutonium production reactors. Whereas the primary purpose of plutonium production reactors is to produce plutonium, nuclear power reactors are intended for power generation, while plutonium is a byproduct of this process.

The International Atomic Energy Agency (IAEA) was established for the purpose of promoting international cooperation in the area of peaceful uses of nuclear energy while preventing the diversion of nuclear material from peaceful nuclear activities to the manufacture of nuclear explosive devices. This organization gives special attention to the production and handling of materials, which can be used for manufacturing nuclear explosive devices, in particular, plutonium. Corresponding facilities in the non-nuclear-weapons states parties of the Non-proliferation Treaty (NPT) are placed under the IAEA safeguards, and are subject to monitoring and inspections.

Over the last 30 years, nuclear weapons have been developed by five states outside the official nuclear club. In addition to India, Pakistan, Israel and North Korea, they were developed in South Africa, which however gave up nuclear weapons later and eliminated its small nuclear stockpile under the supervision of IAEA. Several states have sought to start their nuclear weapons programs, but did not cross the “red line”. Some states have advanced their nuclear technology to the level allowing them to manufacture nuclear weapons in a year or two, if this becomes necessary and if a respective political decision is taken. All this is indicative of certain instability of the existing nuclear non-proliferation regime.

Proliferation risks are determined by political, military and technological incentives to develop nuclear weapons and by the proliferation potential.

The proliferation potential is determined by the availability of nuclear materials, nuclear technologies, special technologies and personnel needed for the development of nuclear weapons. Since the mid-20th century, all the constituents of this potential have been growing continuously. This growth is largely associated with the development of nuclear power engineering, and is basically a by-process related to the dual-use nature of nuclear technologies. Among the major constituents of this potential, let us emphasize the growth in production and stock of reactor-grade plutonium as a by-product of nuclear power engineering.

What determines the relevance of this book? First of all, it is the fact that plutonium produced in nuclear reactors is a mixture of five isotopes Pu-239, Pu-240, Pu-241, Pu-242 and Pu-238 (in the descending order of their content in most plutonium materials), the isotopic composition of which has a considerable influence on the properties of plutonium. There exists a stereotype, according to which weapon-grade plutonium should contain at least 93% plutonium-239 and no more than 7% plutonium-240, while all the other combinations are different types of plutonium. As any stereotype dating back to the early 1960s, it does not completely correspond to the situation in the early 21st century and may lead to the underestimation of the nuclear weapons proliferation risks.

Within this study, we made an attempt to analyze the properties of all major isotopic compositions of reactor-grade plutonium and assess comparative proliferation risks associated with these materials. At the same time, we conducted an independent “inventory check" of the production of such plutonium materials by their type, the type of nuclear reactor and by countries. We hope that this study will contribute to the strengthening of nuclear non-proliferation, probably within the framework of the currently discussed Fissile Material Cut-Off Treaty.

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It is important to note that all the assessments and conclusions presented in the book are the sole responsibility of the authors. They in no way reflect the views of the John D. and Catherine T. MacArthur Foundation or any other institutions.