



Determining Nuclear Fingerprints: Glove Boxes, Radiation Protection, and the International Atomic Energy Agency

Maria Rentetzi*

National Technical University of Athens, Department of Humanities, Social Sciences and Law, School of Applied Mathematics and Physical Sciences, Zografou Campus, Zografou 15780, Athens, Greece

In a nuclear laboratory, a glove box is a windowed, sealed container equipped with two flexible gloves that allow the user to manipulate nuclear materials from the outside in an ostensibly safe environment. As a routine laboratory device, it invites neglect from historians and storytellers of science. Yet, since especially the Gulf War, glove boxes have put the interdependence of science, diplomacy, and politics into clear relief. Standing at the intersection of history of science and international history, technological materials and devices such as the glove box can provide penetrating insight into the role of international diplomatic organizations to the global circulation and control of scientific knowledge. The focus here is on the International Atomic Energy Agency.

On June 13, 2014, the front page of an International Atomic Energy Agency (IAEA) news release featured Gabriele Voigt, director of the IAEA Office of Safeguards Analytical Services, together with Vladimir Sucha, the European Commission Director General of the Joint Research Center, in front of a large glove box. The heading read, “Nuclear Material Laboratory: Meeting Milestones Toward Full Operation.”¹ What they considered to be a milestone was the delivery of the first of twenty brand-new glove boxes to the safeguards laboratory—currently the Nuclear Material Laboratory—that would enable safe handling of nuclear materials. “By the end of 2014,” argued Mark Scheland from the Department of Safeguards, “the IAEA will be operating a state-of-the art laboratory to help

carry out one of its core functions—providing credible assurance that states are not diverting nuclear material from peaceful purposes.”²

A product of the Nuclear Non-Proliferation Treaty that came into force in 1970, the first Safeguards Analytical Laboratory was established in 1967, in a facility leased by the IAEA, in order to detect the misuse of nuclear materials and technology and to ensure that member states were honoring their safeguards obligations. As provided by the treaty, the IAEA had a mandate to verify that a member state was living up to its commitment to use nuclear materials for peaceful purposes and not for making nuclear weapons. As part of the verification process, nuclear samples collected by IAEA safeguards inspectors from nuclear fuel cycle processes were sent for analysis to the Safeguards Analytical Laboratory. Given the highly sensitive nature of samples derived from inspections in nuclear facilities worldwide, each of these analyses was and is still performed in a restricted and controlled area of the IAEA laboratory specially equipped to avoid cross contamination and tampering with samples. The glove box played a key role in this process. Using state-of-the-art instruments such as glove boxes allowed IAEA researchers to accurately analyze radioactive swipe samples in a safe environment, determine minute traces of uranium or plutonium, and detect illicit uranium enrichment activity (Figure 1).

As David Donohue, previously the head of the IAEA Clean Laboratory for Safeguards, described the process:

Analysis of samples can determine ‘nuclear fingerprints’, and reveal indicators of past and current activities in locations handling nuclear materials, particularly those associated with uranium conversion, fabrication, and enrichment. Determining such cases, however, requires expertise and the right equipment—the fingerprints of different isotopes,

*Fax: +30 210 7721618.

E-mail address: mrentetzi@vt.edu

URL: <http://mariarentetzi.weebly.com/>

¹ International Atomic Energy Agency, “Nuclear Material Laboratory: Meeting Milestones Toward Full Operation,” accessed January 31, 2017, <https://www.iaea.org/newscenter/news/nuclear-material-laboratory-meeting-milestones-towards-full-operation>. The photograph can be viewed at the link above. Its caption reads: “Ms. Gabriele Voigt, Director, IAEA Office of Safeguards Analytical Services, and Mr. Vladimir Sucha, European Commission Director General for the Joint Research Center, inaugurate the first newly installed laboratory glove box in the IAEA Nuclear Material Laboratory.”

² Mark Scheland, “Nuclear Material Laboratory: Meeting Milestones Wards Full Operation,” IAEA News Release, June 13, 2014, <https://www.iaea.org/newscenter/news/nuclear-material-laboratory-meeting-milestones-towards-full-operation>.



Figure 1. Shown is a series of glove boxes, which permit gram quantities of plutonium to be processed for analysis at the IAEA's Safeguards Analytical Laboratory, 1985. (Courtesy of the Archives of the International Atomic Energy Agency, no. A0739).

for example, can overlap, and an abundant constituent of one element can mask a rare one. Reaching conclusions can be tricky, often requiring multiple dimensional analytical approaches.³

In the mid-2000s it became obvious that IAEA could no longer meet the high demand for its analytical services using an aged facility that did not even meet the United Nations safety requirements. A modernization program was soon put forward in order to improve IAEA's analytical capabilities by completely renovating the safeguards laboratories. Glove boxes, as Voigt's and Sucha's photograph indicates, became the emblem of IAEA's modernization. The agency spent €0.680 million for the disposal of older glove boxes and €77.16 million in total for the

modernization of its laboratories, generously sponsored by the European Union.⁴

But why, in 2014, did the IAEA trumpet the installation of glove boxes, which were among the first and most rudimentary tools of nuclear science, dating from the mid-1940s? Standing at the intersection of history of science and international history, technological materials and devices can provide penetrating insight into the role of international diplomatic organizations in the global circulation and control of scientific knowledge. Material objects define and contain the activities of scientific organizations. In the case of the IAEA, the glove box did not only have actual practical necessity, as a way to provide a safe and clean working environment. It had also symbolic significance to a newly redefined agency. The glove box, as a symbol, both points to major and real concerns over international nuclear security and underlines a significant evolution in the IAEA's mission. From promoting peaceful uses of nuclear energy and isotopes throughout the second half of the twentieth century, the IAEA of the twenty-first century has sifted focus—through elegant diplomatic negotiations—to more oversight authority, establishing a critical and influential policy mechanism in order to enforce the Nuclear Non-Proliferation Treaty in member states.

Without a doubt, the IAEA has played a crucial role in a number of scientific, political, and diplomatic issues ranging from the establishment of nuclear industry and the offer of technical assistance and the education of generations of scientists in nuclear matters in a number of countries worldwide to the exercise of political power and diplomatic influence in order to safeguard the use of nuclear energy. Operating at the intersection of nuclear science and diplomacy, the IAEA has attracted immense political attention throughout the second half of the twentieth century and continues to do so as we move well into the twenty-first. The growing presence of scientific and technical experts in IAEA's diplomatic affairs and the agency's central role in settling global scientific issues make clear that the precondition for any scientific collaboration among nations has been their political cooperation. This increasing intimacy of postwar nuclear science with global diplomacy and the need of exhaustive diplomatic negotiations in order to settle scientific issues on a global scale necessitates a diplomatic turn in the history of science: diplomacy becomes central in analyzing postwar science and technology. Attention to global diplomacy becomes necessary to understand how scientific knowledge and technological materials have been shaped in reference to and shaped the course of nuclear matters. Given the sensitive intertwinement of science and diplomacy throughout the IAEA's history, it is problematic that this has been largely left to in-house historians. At the same time, the rich material culture of IAEA's laboratories has been neglected. Here I began to fill in the history of both.

³ David Donohue, "Key Tools for Nuclear Inspections: Advances in Environmental Sampling Strengthen Safeguards," *Bulletin of the IAEA* 44, no. 2 (2002): 17–23, on 20. The Clean Laboratory provides assurance that no undeclared activities have occurred in any member states while the Nuclear Material Laboratory provides assurance that member states are providing accurate information concerning the types and quantities of nuclear materials held on their territory.

⁴ Caroline Aggestan-Pontoppida and Isabell Andernack, *Interpretation and Application of IPSAS* (Chichester, UK: Wiley, 2016), 267; Green Andrew and Aabha Dixit, "IAEA Safeguards Labs More Efficient and Accurate Thanks to Recent Upgrades," IAEA Press Release, June 10, 2016, <https://www.iaea.org/newscenter/news/iaea-safeguards-labs-more-efficient-and-accurate-thanks-to-recent-upgrades>.

Glove Boxes: The Shift from Radiation Protection to Nuclear Security

Throughout the early twentieth century, physicists, biologists, and physicians were confronted with ionizing radiation, a challenge that simultaneously proved hazardous and sparked innovations. Scientists struggled to define an appropriate unit of radiation, invent suitable measurement devices, detect and agree on the effects of radiation on biological systems, and identify the acceptable risk of radiation exposure. The evolution of standards and the scientific controversies that emerged reflect the complexity and messiness of scientists' collaborative production and dissemination of what eventually comes to be considered to be objective and reliable knowledge. It also reveals the powerful role of those scientific institutions that took on the task of creating these standards. From the German Roentgen Society and its first recommendations to users of X-ray technologies in 1913, to the establishment of the field of "health physics" at the Metallurgical Laboratory of the University of Chicago during World War II, scientific institutions forged new attitudes toward acceptable radiation risks, tolerable radiation doses, and radiation protection.

Before World War II the term radiation protection signified mainly the protection against radiation risks associated with radium and X-rays. Those working in university laboratories conducting research on radioactivity often ignored radiation hazards altogether. The Cavendish laboratory manager George Crowe disregarded the only laboratory safety rule to wear rubber gloves to protect his skin from radiation burns. In Vienna, during the 1910s, when Otto Hönigschmidt carried out his atomic weight experiments, he homogenized the radium solution shaking it by hand. Stefan Meyer, director of the Vienna Radium Institute, assured his personnel that protective masks were not needed when opening sealed tubes with radium salts, even throughout the 1920s.⁵

The community of radiologists was more concerned. In 1922 George Edward Pfahler, the most prominent radiologist in the United States, took up a major concern within the community of radiologist, the safety issues of handling X-rays and radium. He was heading the American Radium Society and was also president of the American College of Radiology. He argued that "as the amount of radium used in medical practice increases, and as x-rays are being made more powerful, we may be facing new dangers. It is better that we investigate now."⁶ By 1929, triggered by the stream of deaths among laboratory workers who handled radioactive materials, all major radiological societies in the United States joined forces in establishing the Advisory Committee on X-Ray and Radium Protection. Representatives of the American Roentgen Society, the American Medical Association, the Radiological Society of North America, the National Bureau of Standards (which, in the meantime, was running its own investigations of

workers engaged in measuring samples against the Bureau's radium standard), and even the equipment manufacturers were members of the advisory committee. Serving as the analog of the International X-Ray and Radium Protection Committee (known after 1950 as ICRP) created a year earlier, the US committee adopted the recommendations of its English counterpart. Yet by the end of the 1920s, industrial laboratories continued to pay scant attention to the safety of their workers who were often left alone to address issues of control and safety individually.⁷

A major shift in radiation protection occurred in radium industry in early 1930s. Among the most profitable industries in the United States, radium factories had employed young women to paint the dials on watches and instruments with radioactive paint since the early 1910s. By the mid-1920s, numerous dial painters from the major dial painting studios suffered from radium poisoning and many of them went through painful and abhorrent deaths. Only in 1933 did the US Public Health Service suggested safe practice guidelines for painting luminous watch dials.⁸ With the outbreak of World War II, the US Army and Navy needed a number of luminous instruments, and so dial painters were urgently employed. The US Department of Health pressed for occupational protection standards in the dial painting industry. It was the US Navy Medical Corps who literally forced Robley Evans, a physicist at the California Institute of Technology and an expert in radium poisoning, to collaborate on the project. By 1944 a committee responsible for radiation protection standards from the Manhattan Project consulted Evans in order to establish safety equipment and procedures for their own laboratories.⁹

Eventually, during the interwar period, radiation protection shifted from being a secondary concern of radiologists and radiological physicists to becoming the subject of a new discipline.¹⁰ That was when glove boxes

⁷ Daniel Powel Serwer, "The Rise of Radiation Protection" (PhD dissertation, Princeton University, 1977).

⁸ Clark, Claudia, *Radium Girls: Women and Industrial Health Reform, 1910–1935* (Chapel Hill, NC: The University of North Carolina Press, 1997). Concerning the other important group of workers related to the radium industry, the miners, research on their health condition came equally late. The first epidemiological studies of the lung carcinoma that often appeared as the main cause of death in uranium miners at Joachimsthal in West Bohemia were conducted in early 1930s. Emilie Tesinska, "Epidemiological Studies of Lung Carcinoma Incidence in Uranium Miners," *Prague Medical Report* 110, no. 2 (2009): 165–70.

⁹ Maria Rentetzi, "Women Radium Dial Painters as Experimental Subjects or What Counts as Human Experimentation," in *Twentieth Century Ethics of Human Subjects Research: Historical Perspectives on Values, Practices, and Regulations*, ed. Roelcke Volker and Giovanni Maio (Stuttgart: Franz Steiner, 2004) 275–91.

¹⁰ See, for example, Isaac Asimov and Theodosius Dobzhansky, *The Genetic Effects of Radiation* (US Atomic Energy Commission, Division of Technical Information, 1966); Roger Clarke and Jack Valentin, "The History of ICRP and the Evolution of its Politics," *Annals of the ICRP* 39, no. 3 (2009): 75–86; Catherine Caufield, *Multiple Exposures: Chronicles of the Radiation Age* (Chicago: University of Chicago Press, 1989); Bettyann Kevles, *Naked to the Bone: Medical Imaging in the Twentieth Century* (New Brunswick, NJ: Rutgers University Press, 1997); R. Preston, "Radiation Biology: Concepts for Radiation Protection," *Health Physics* 88 (2005): 545–56; D. P. Serwer, *The Rise of Radiation Protection: Science, Medicine and Technology in Society 1896–1935*, Brookhaven National Laboratory Report BNL-22279, December 1976; Lauriston Taylor, *Radiation Protection Standards* (Boca Raton, FL: CRC Press, 1971); *Organization for Radiation Protection: The Operations of the ICRP and NCRP, 1928–1974* (Washington, DC: National Technical Information Service, 1979); Samuel Walker and Thomas Wellok, "A Short History of Nuclear Regulation, 1946–2009," US Nuclear Regulatory Commission report no. NUREG/BR-0175, Revision 2, 2010, <http://large.stanford.edu/courses/2015/ph241/baumer2/docs/ML102980443.pdf>; Gilbert F. Whittemore, *The National Committee on Radiation Protection, 1928–1960: From Professional Guidelines to Government Regulation* (PhD dissertation, Harvard University, 1986).

⁵ Timothy Jorgensen, *Strange Glow: The Story of Radiation* (Princeton: Princeton University Press, 2016), 67. Maria Rentetzi, *Trafficking Materials and Gendered Experimental Practices: Radium Research in Early 20th Century Vienna* (New York: Columbia University Press, 2008), chapter 2, esp. 34–36, <http://www.gutenberg-e.org/rentetzi/chapter02.html#txt43>.

⁶ George E. Pfahler, "The Effects of the X-Rays and Radium on the Blood and General Health of Radiologists," *American Journal of Roentgenology* 9 (1922): 647–56, on 647.

made their appearance. The idea behind their design was to ensure minimum risk to workers dealing with radioactive materials in nuclear facilities and defense laboratories during World War II. The atomic weapons program drove the development of the first such protective devices.¹¹ Early boxes were fabricated of stainless steel with windows of safety glass. The metal parts inside the box were painted with a strippable plastic base paint. The earliest type of enclosed protective equipment was actually the dust box, a closed cylinder two to four feet in diameter and two to three feet tall. The lower part of the cylinder was closed by metal while the upper part was covered with glass, allowing a view of the interior. Two closed armholes equipped with long-sleeved rubber gloves protected the workers from alpha emitters and allowed safe manipulation of highly dangerous materials such as plutonium.

In the experimental laboratories and the production plants where nuclear fission was in operation, researchers had to recognize that handling radioactive materials could have lifelong consequences; they had to be constantly aware of possible radiation risks and prevent contamination. The new challenge was to persuade them that unnecessary exposure to radiation had biological effects and train them to handle hazardous materials properly. Those working with radioactive sources had to be shielded against three different kinds of radiation: alpha, beta, and gamma rays. Although shielding against alpha radiation involved simply the use of rubber gloves that prevented contamination of the skin, beta and gamma rays required handling distant sources by remote control.¹² The lack of medical knowledge of radiation overexposure led to wider use of glove boxes as a preventive measure. The objective was clear in a 1946 classified report of the Argonne National Laboratory: "Our present means of therapy of persons who are over-exposed to external radiations or of persons who have dangerous quantities of radioactive materials deposited in their bodies leaves much to be desired. Practically speaking there is no rational or specific treatment for the disorders induced by these radiations. As a consequence, protection of the worker from these substances is of the utmost importance."¹³

In the aftermath of the bombings of Hiroshima and Nagasaki, conceptualization of radiation protection changed radically. The new scientific evidence of genetic and somatic effects at lower doses of radiation led the ICRP to revise downward their prewar radiation protection recommendations. The widespread use of radioactive materials in industry, the broad public concern about the effects of radiation, as well as the rapid development

and adoption of new medical technologies such as radio-isotope-teletherapy units and the growth of the nuclear power industry, posed numerous challenges in the field of radiation protection. The rise of radiotherapy and the introduction of medical technologies into the clinic were closely connected to the military strategies of the US Atomic Energy Commission during the Cold War.¹⁴ The mass quantities and new types of radiation and radioactive materials led to new approaches in the field and created the space for the international regulation of radiation risks. The transition from pre- to postwar nuclear science and technology was marked by a shift in emphasis from radiation protection to nuclear safety.¹⁵ Gradually, glove boxes were introduced to all big nuclear experimental laboratories and production plants. But despite the fact that training manuals highlighted the importance of their use for worker's safety, radiation protection did not always ensue. Glove boxes themselves proved to be a serious source of accidental overexposure. The following examples are illustrative.

On June 12, 1964, an employee was working in a glove box preparing plutonium triggers for hydrogen bombs at the US Rocky Flats Division, operated by the Dow Chemical Company. When he accidentally dropped plutonium in a chemical bath, the box exploded instantly. Its window was shattered and plutonium contaminated the working area. The operator, a male chemist, seriously injured his gloved left hand and was exposed to a high concentration of airborne plutonium. His case, among many others, contributed to the determination of acceptable radiation doses in the human body (Figure 2).¹⁶

The case most widely discussed is that of Harold McCluskey, which occurred on August 30, 1976. McCluskey, a sixty-four-year-old chemical technician, was working at the Plutonium Finishing Plant of the Hanford Nuclear Reservation, a major US site for the production of plutonium during the Manhattan Project. The site was established in 1949 for the production of plutonium metal for nuclear weapons. McCluskey was responsible for producing americium 241, a plutonium byproduct. Along with his colleagues, he had just returned to work after a successful five-month strike demanding increased wages. After that time, the radioactive material he was working with had become unstable. As soon as he handled the chemicals, the glove box ruptured, exposing him to a massive dose of radiation. In a few seconds, he absorbed 500 times the allowable lifetime dose. No one had seen anything similar until then, as his physician reported. According to the *Seattle Times*, McCluskey was "too hot to handle" and "was removed by remote control and transported to a

¹¹ C. J. Barton, *A Review of Glove Box Construction and Experimentation* (Oak Ridge, TN: Oak Ridge National Laboratory, 1961); Tim Coles, *Isolation Technology: A Practical Guide* (Boca Raton, FL: CRC Press, 2004).

¹² External exposure to alpha emitters presents low health risk in contrast to internal exposure, which has serious biological effects and increases the risk of cancer.

¹³ J. J. Nickson, "Protective Measures for Personnel," Argonne National Laboratory, report received on 30 January 1947, operated by the University of Chicago under contract no. W-31-109-eng-38, 1, <http://digital.library.unt.edu/ark%3A67531/metadc624550/>.

¹⁴ Ellen Leopold, *Under the Radar: Cancer and the Cold War Critical Issues in Health and Medicine* (New Brunswick, NJ: Rutgers University Press, 2009); Gerald Kutcher, *Contested Medicine: Cancer Research and the Military* (Chicago: University of Chicago Press, 2009).

¹⁵ According to the IAEA glossary, the ways we use the two terms today are the following: radiation protection refers to the protection of people and the environment against radiation risks while nuclear safety denotes the safety of facilities and activities that give rise to radiation risks. IAEA Safety Glossary, *Terminology Used in Nuclear Safety and Radiation Protection* (Vienna: IAEA, 2007), 2.

¹⁶ E. A. Putzier et al., "Acute Internal Exposure to Plutonium," in *Personnel Dosimetry for Radiation Accidents* (Vienna: IAEA, 1965), 551–66.

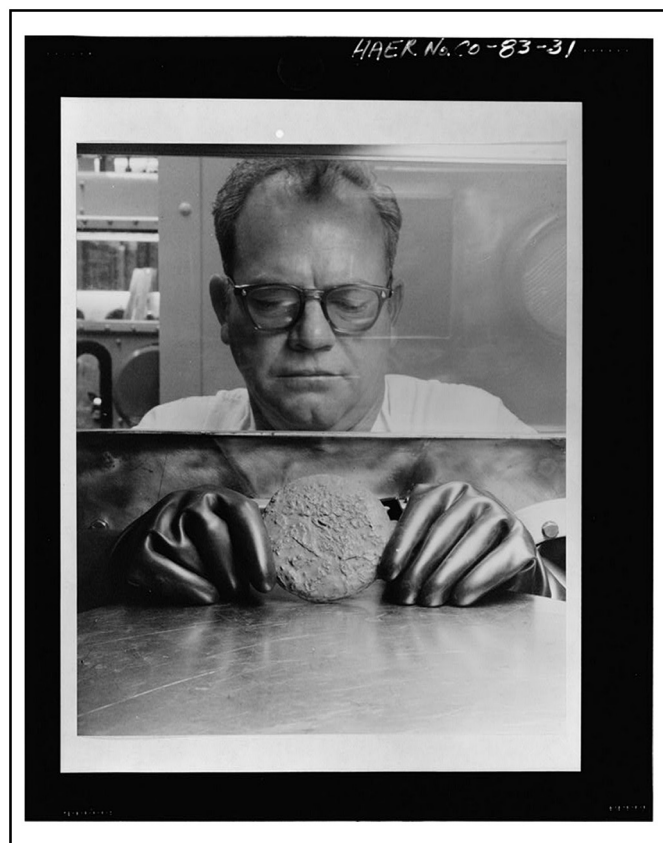


Figure 2. A worker at the Rocky Flats Plant is holding a “plutonium button” inside a glove box, 1973. Using the “safe” environment of a glove box, employees at Rocky Flats reprocessed plutonium scraps resulting from production and plutonium recovered from retired nuclear weapons into valuable pure-plutonium metal. (Courtesy of the Library of Congress, <http://www.loc.gov/pictures/item/co0471.photos.316830p/>).

steel-and-concrete isolation tank.” He made medical history, surviving the accident and living eleven more years.¹⁷

Despite the postwar emphasis on nuclear safety, accidents continued well into the 1980s. In order to further promote safety and quality of glove box systems and to develop standards and guidelines for glove box technology, a group of nuclear engineers formed the American Glove Box Society in 1986. Three years later, the Society’s newsletter reported extensively on the Family Day Glove Box Display that took place at the Oak Ridge Y-12 Plant. During World War II, the plant was part of the Manhattan Project, where uranium was enriched for the first atomic bombs. Throughout the 1980s, however, it attracted the interest of anti-nuclear protesters. Thus, it is not by chance that in 1989 the plant opened its doors providing “a rare opportunity to educate the public about glove boxes. Family members of employees were given a four-hour tour of the

¹⁷ James Mahaffey, *Atomic Accidents: A History of Meltdowns and Disasters* (New York: Pegasus 2014). The room where the accident took place was named after McCluskey and remained closed since then. Operating for over forty years, the Plutonium Finishing Plant has been characterized by the US Department of Energy (DOE) as the most complex and hazardous facility in the country. Since 2009, DOE has been working on cleaning up the site and demolishing the buildings. By July 2014, at least 213 out of 238 glove boxes were cleaned out and removed. “The McCluskey Room,” as the DOE representative argued, “is going to be the toughest work ahead of us as we finish cleaning the plant and getting it ready for demolition by the end of September 2016.” See Nicholas Geranios, “Feds to Clean Site of Hanford’s 1976 ‘Atomic Man’ Accident,” *The Seattle Times*, July 2, 2014.

facility. The Y-12 plant is normally closed to the public,” as we are informed, but “extra security measures were taken to make the DOE approved tour possible.” The event was considered a tremendous success. “Many questions such as ‘What is it?’, ‘What’s a glovebox?’, and ‘Why can’t you...?’ as well as ‘What do you do for a living, Daddy?’ were answered by the display.” Needless to say, such facilities were male dominated.¹⁸

In these early days, promoting glove boxes in the nuclear industry and research laboratories served a twofold purpose: it created what often proved to be an illusion of a safe work environment for those involved in production and research and at the same time eased the way to nuclear regulations. By the end of the 1950s, the international nuclear regulatory system started to take shape as result of the geopolitical division of the Cold War. By the mid-1980s, regulation had become an instrument of social management and a matter of political dispute among UN agencies, established international disciplinary organizations, state and non-state actors, groups of prominent scientists, and uneasy diplomats. By early 1990s the focus shifted once again, this time from nuclear safety to security as the result of the Iraqi crisis and an indication of the new IAEA safeguards systems that took shape following it. Glove boxes proved to be central in this shift while nuclear forensics—the analysis of nuclear material for purposes of national security—was deployed to address cases of illegal smuggling of nuclear materials during this period. It was the time that the idea of collecting and analyzing swipe samples as forensic evidence of nuclear unauthorized activities was born.¹⁹

This last part of the history of radiation protection transcends national borders. It enters into a broader context of international politics and diplomatic negotiations where centralized global institutions and science diplomats played significant roles. The IAEA, the only United Nations body with specific statutory responsibilities for radiation protection and safety in all sectors, features prominently in this story.

The Establishment of the IAEA and Its Safeguards System

Immediately after the end of World War II, Clement Richard Attlee, England’s Prime Minister, urged US President Harry Truman and Canadian Prime Minister Mackenzie

¹⁸ “Y-12 Family Day Glove Box Display ... A Big Success,” *The Enclosure*, American Glove Box Society 3, no. 2 (1989): 5. The few women who were employed by nuclear industries to operate glove boxes were seen as intruders by their male colleagues. According to one of them, Jacqueline Brever, who was hired at Rocky Flats in 1982 and worked as chemical operator, “back in those days, very few women did that job. And the men did not like it AT ALL; they had a little club going on in there for, what, 30 years? So, here come all these women, and a lot of them did not like it.” See Jacqueline Brever, interview with LeRoy Moore, June 4, 1999, Boulder Library, Maria Rogers Oral History Program at the Carnegie Library for Local History, <http://oralhistory.boulderlibrary.org/transcript/oh1498t.pdf>.

¹⁹ Vitaly Fedchenko, ed., *The New Nuclear Forensics: Analysis of Nuclear Materials for Security Purposes* (Oxford: Oxford University Press, 2015). Today nuclear forensics denotes “the technical means by which nuclear materials, whether intercepted intact or retrieved from post-explosion debris, are characterized (as to composition, physical condition, age, provenance, history) and interpreted (as to provenance, industrial history and implications for nuclear device design).” Nuclear forensics is necessarily combined with law enforcements and intelligence data. Joint Working Group of the American Physical Society and the American Association for the Advancement of Science, *Nuclear Forensics: Role, State of the Art, Program Needs* (APS & AAAS, 2008), 9.

King to meet in Washington to discuss their wartime atomic agreements and the control of atomic energy. On November 15, 1945, they issued a “Three State Declaration on Atomic Energy” aiming at international control of atomic energy. They were aware that the only protection from the misuse of nuclear energy was the prevention of war and that no system of safeguards could be devised to provide an effective guarantee against production of atomic weapons. “We are, however, prepared to share, on a reciprocal basis with others of the United Nations, detailed information concerning the practical industrial application of atomic energy just as soon as effective enforceable safeguards against its use for destructive purposes can be devised,” they declared. It was the first time that the idea of safeguarding nuclear energy was clearly on the table. The real fear was that, without control, the international nuclear trade could lead to nuclear proliferation.²⁰

Soon thereafter, Vannevar Bush, former science advisor to President Roosevelt and overall an “engineer of the American century,” suggested a study committee to Secretary of State James Byrnes “to study the subject of controls and safeguards necessary to protect this Government . . . anticipating favorable action by the United Nations Organization on the proposal for the establishment of a commission to consider the problems arising as to the control of atomic energy and other weapons of possible mass destruction.”²¹ Bush suggested bringing the Soviet Union into the negotiations. Finally, in December 1945, the Soviet Union accepted the proposal. As a result, in January 1946, the first session of the United Nations General Assembly approved the creation of an Atomic Energy Commission (UNAEC) that aimed to elevate the control of atomic energy to an international level.

Meanwhile, two documents shaped Americans’ attitude toward nuclear energy. The first, *One World or None*, an eighty-six-page paperback published by the Federation of American Scientists, promised to be “a report to the public on the full meaning of the atomic bomb.”²² Forwarded by Niels Bohr and with an extended introduction by Arthur Compton, the book was written by a number of prominent scientists to promote “the peaceful atom” and described the potential horrors of atomic bombs. The second, the Acheson-Lilienthal Report, represented the scientists’ most coherent view of what the international control of atomic energy could mean. Major elements of the report were later incorporated to the Baruch plan, named by Bernard Baruch, the first US representative to the United Nations. As an early instance of nuclear non-proliferation, the plan asked for the establishment of an “international atomic

development authority,” and some form of preliminary safeguard system, which, by means of inspection and control of nuclear materials, could protect complying states against those that violated the agreement.²³

The Baruch plan was rejected by the Soviet Union and remained the official American policy only until 1953.²⁴ Given the frozen positions of the United States and the Soviet Union, the UNAEC in 1948 reported that there was no obvious reason to carry on further negotiations in the General Assembly. The committee was formally abolished in 1952. Concerning safeguards, the United States required their application only to those bilateral agreements that the country signed with other nations when providing nuclear technologies, radioactive materials, and expertise. By the end of 1959, the United States had indeed signed forty-two bilateral agreements for the establishment of experimental reactors worldwide. The same safeguards system was in effect for the British and Canadian agreements.

In the midst of the Cold War, the Eisenhower Administration proposed a plan more modest than the Baruch plan, which led to the creation of the International Atomic Energy Agency in 1957. Eisenhower told the General Assembly on December 8, 1953: “We would expect that such an agency would be set under the aegis of the United Nations.” The most important responsibility of the agency would be to devise appropriate methods for the available fissionable material to serve only the peaceful uses of atomic energy. The second objective was to develop the nuclear industry so as to provide electrical energy in the “power-starved areas of the world.” Finally, the third major objective was related to the issue of disarmament, although was not presented clearly as such. Eisenhower’s plan was to “begin to diminish the potential destructive power of the world’s atomic stockpiles.”²⁵

Bernhard Bechhoefer, an attorney who acted as a special assistant to the US representative during the negotiations that followed Eisenhower’s proposal, characterized it as a “splendid performance,” a speech that revealed the president’s decision to shift the emphasis from the destructive potentials of nuclear weapons to the peaceful uses of the atom.²⁶ According to John Hall, Deputy Director of the IAEA from 1961 to 1964, Eisenhower’s success was based rather on his limited nuclear disarmament plan and modest regulatory proposal.²⁷ Despite the different interpretations, what is peculiar about this proposal is that it actually worked out. As the US Ambassador to the United Nations James Wadsworth claimed in 1956 the negotiations for the establishment of the IAEA were the most successful East-West negotiations since the end of World War II. Bechhoefer and Eric Stein, professor of law at the University of Michigan and an advisor to the US representative,

²⁰ Atomic Energy, Agreed declaration signed at Washington, November 15, 1945. Entered into force November 15, 1945, <https://www.loc.gov/law/help/us-treaties/beans/m-ust000003-1304.pdf>. See also *The Evolution of IAEA Safeguards*, International Nuclear Verification Series 2 (Vienna: IAEA, 1998), http://www-pub.iaea.org/MTCD/Publications/PDF/NVS2_web.pdf.

²¹ Joseph Preston Baratta, *The Politics of World Federation: Unabated Nations, UN Reform, Atomic Control* (Westport, CT: Praeger, 2004); John Hall, “The International Atomic Energy Agency: Origins and Early Years,” *IAEA Bulletin* 2 (1987): 47–54; Zachary Pascal, *Endless Frontier: Engineer of the American Century* (Cambridge, MA: MIT Press, 1999). See also the Acheson-Lilienthal Report: Committee on Atomic Energy, *A Report on the International Control of Atomic Energy*, Department of State Publication 2498 (Washington, DC: US Government Printing Office, 1946).

²² Dexter Masters and Katharine Way, *One World or None: a Report to the Public on the Full Meaning of the Atomic Bomb* (New York: McGraw Hill, 1946).

²³ The Baruch Plan speech is reprinted in: Bernard M. Baruch, “The American Proposal for International Control,” *Bulletin of the Atomic Scientists* 2, nos. 1 and 2 (1946): 3–5, 10.

²⁴ Bertrand Goldschmidt, “A Forerunner of the NPT? The Soviet Proposals of 1947,” *IAEA Bulletin*, 28, no. 1 (1986): 58–64.

²⁵ Eisenhower’s speech is available online at: http://www.eisenhower.archives.gov/research/online_documents/atoms_for_peace/Binder13.pdf.

²⁶ Bernhard Bechhoefer, “Negotiating the Statue of the International Atomic Energy Agency,” *International Organization*, 13, no. 1 (1959): 38–59, 40.

²⁷ Hall, “International Atomic Energy Agency” (ref. 21).

carefully documented the six separate stages of the negotiation process: (1) the secretive bilateral exchanges between the United States and the Soviet Union throughout 1954 and 1955, which came to a futile end while the Soviets insisted on their own disarmament suggestions; (2) the discussion of the issue during the ninth United Nations assembly in 1954 wherein the United States determined to go ahead even without Soviet agreement; (3) the initiative of the Americans to include eight states in an informal discussion about the establishment of the agency;²⁸ and (4) the discussion of the draft of the agency's statute that came from the previous year's General Assembly. In the meantime, the negotiating group had been enlarged to include the Soviet Union, Czechoslovakia, India, and Brazil. By the end of the Assembly, the Statute had been transmitted to eighty-four member states.

The fifth stage, known as the "working level meeting" among the twelve negotiating states, secured an agreement and submitted a final text of the IAEA statute to the International United Nations Conference of eighty-one states met in October 1956. That meeting marked the final stage of the negotiations process when it reached unanimous agreement and adopted the IAEA statute on 23 October. Sterling Cole, a lawyer and US Republican congressman, attended the meeting as a member of the Congress and advisor to the American delegation. "While I was there" Cole recalled, "I had a letter from [Lewis] Strauss saying that he had talked with Eisenhower and with [John Foster] Dulles about the director generalship of IAEA and they both agreed that I should be nominated for it by the U.S."²⁹ Yet, there had been the understanding that the first Director General of such a scientifically specialized international agency ought to be a scientist from a neutral country. Cole's candidacy announced at a *New York Times* article in August 1957 reinforced Cold War strains. It also signaled a shift toward diplomacy as means in settling scientific issues on a global scale.³⁰

As a next step, a preparatory commission came into existence after the IAEA statute was opened for signature. Composed by an enlarged group of member states, it remained in existence until the United Nations General Conference of 1957, when the statute was ratified by twenty-six member states and entered into force on July 29, 1957. As Cole later described in an interview: "In September of 1957 the agency started. On October 4 I was elected unanimously by all of the country members. Also on October 4 was the announcement of the first successful Sputnik. I chided the Russians for deliberately using this date to demonstrate their terrific accomplishments in science technology, thereby putting news of my election as director general on the back page."³¹ Diplomacy

mattered a great deal. In the widely circulated IAEA *Bulletin*, Cole described the establishment of the agency in a triumphal way: "Thanks to the forceful initiative of the scientists of the world, the atom has been taken from its fictional black box of secrecy and placed in the sum of human enlightenment. Tremendous progress has been made. Close your eyes for a moment and think back to the atomic world of 1953 then open them to the world of today. The contrast is the difference between darkness and light."³²

The enthusiasm and great expectations of the IAEA's first years have been demonstrated in several cases. For example, in 1960, Gunnar Randers, then member of IAEA's Board of Governors, pointed out what he believed was the most peculiar feature of the new organization: "The IAEA is generally considered to be a technical agency. That means it is supposed to center its activities around certain specialized technical problems. . . Solving technical problems should be possible without stumbling over political obstacles."³³ A Norwegian physicist and director of the Norwegian Atomic Energy Institute, Randers had been asked that year to chair a committee of experts on the application of safeguards to reactors smaller than 100 MW, which were chiefly research and experimental reactors. Yet, in an article at the *Bulletin of the Atomic Scientists* in 1961, Randers declared: "I now believe that the question is not as simple as that. . . The IAEA cannot be considered a purely technical organization—rather, one could call it a techno-political organization. . . When a technical matter has left the laboratories of purely academic research and, begins to touch upon these questions [meaning future industry, armament, and technical assistance] it can no longer be dealt with on an international scale without taking political problems into consideration."³⁴

Randers was not the only one who recognized the close interrelation of science and politics; or, to be more specific, of science and international diplomacy. Sterling Cole, the first Director General of the IAEA was astonished to find out that he was not going to be reelected in 1961, "having been assured by my government before I agreed to serve as director general that this job was not a political plum, subject to rules of patronage when there was change in the administration. I was very disturbed because I thought, of course, until there was some criticism of the work—and I had heard none—I went along thinking that I would be reelected. Never before had the U.S. considered international service to be a political plum."³⁵

Nations welcomed the establishment of the agency for diverse political reasons, but almost all shared the expectation of acquiring nuclear energy in order to bolster industrial development. Yet the IAEA's application of a centralized safeguards system was not equally welcomed. According to David Fischer, Director General of IAEA's External Relations and also its internal historian, "the Agency's safeguards initially encountered mistrust and

²⁸ The eight states were, in addition to the United States, Australia, Belgium, Canada, France, Portugal, the United Kingdom, the Union of South Africa. For the explanation of the reasoning for such a selection see Bechhoefer, "Negotiating the Statute" (ref. 26), 45.

²⁹ Sterling Cole, interview with C. Morrissey, August 24, 1978. W. Sterling Cole papers, col. no. 2081, Division of Rare and Manuscript Collections, Cornell University Library, page 11.

³⁰ David Fischer, *History of the International Atomic Energy Agency* (Vienna: IAEA, 1997), 59; Kathleen McLaughlin, "U.S. Chief Foreseen for World Atom Unit; U.S. Likely to Get World Atom Post Agency Established in July." *The New York Times*. August 16, 1957.

³¹ Cole, interview with Morrissey (ref. 29), 12.

³² Sterling Cole, "Humanity Demands no Less," *IAEA Bulletin* 0-1 (September 1958): 2.

³³ Gunnar Randers, "International Atomic Energy Agency: The Scientist's View," *Bulletin of the Atomic Scientists* 15, no. 4 (1959): 163-67.

³⁴ Gunnar Randers, "What About Vienna?," *Bulletin of the Atomic Scientists* 17, no. 1 (1961): 20-23.

³⁵ Cole, interview with Morrissey (ref. 29), p. 13.

resistance, especially from its developing country members, but also from its Soviet bloc and some West European states intent on protecting Euratom.” The European Atomic Energy Community (Euratom) was actually the first that institutionalized safeguards at a regional level in 1957. Some European countries saw the IAEA’s attempt to establish a safeguards system as a direct threat to Euratom.³⁶ But the international scenery was more complex than this.

The US favored bilateral atomic agreements made directly with other countries or organizations and not through the IAEA. Cole was relentless on his attracts on the philosophy of bilateralism, arguing that bilateral agreements undermined IAEA’s authority. According to him the US was “dangerously and foolishly letting all supplying countries of nuclear materials making their own rules.”³⁷ Cole’s opposition to the US strategy created tensions within his own country. In the US Congress, his fellow Republicans felt uneasy with his insistence to grant more power to the IAEA, while his previous enemies, the Democrats, saw in it a great opportunity to attack Eisenhower’s foreign policies. Being isolated in Vienna, Cole found himself unable to strengthen IAEA’s international role in regulating the circulation of fissionable materials and, in the long run, to get reelected as Director General.

In 1957 the Russians supported the Indian position in opposing effective safeguards. In 1958 the US made clear that they did not want to allow the IAEA to implement any kind of safeguards to its NATO allies. The same year, the Soviet Union opposed any supervision and inspection of countries that received Soviet atomic aid. During the 1958 General Conference, Soviets and Indians together opposed any provision in IAEA’s budget for staffing the Department of Safeguards. The argument was that there were no IAEA projects in the area of safeguards that demanded funding. Having first excluding the possibility of applying safeguards, they were now alleging that there was no such demand. The representative from Japan was among the very few who strongly supported the idea of creating and staffing the Department. As he argued “one must open shop before one can expect to have costumers.”³⁸ When the first safeguards agreement to cover a small Japanese reactor and its fuel came before the agency’s Board of Governors in 1959, a fierce debate ensued once again. It was indicative of the Cold War tensions apparent in the new global geopolitical order. In 1960 Cole circulated a proposed safeguards agreement to the seventy governments belonging to the IAEA at the time. The plan was modest. It demanded on-the-spot inspection visits to countries operated installations with nuclear material obtained through the agency and the agency’s approval of reactor design of the recipient nations. Those countries that did not obtain their nuclear material from the agency were not obliged to accept safeguards inspections. By the end of the day and after sharp diplomatic debates, the IAEA was able

to apply a limited system of safeguards that covered only the research and experimental reactors of the day.

The reluctance of nations to place their programs under international control was smoothen only when the United States decided to transfer to the IAEA responsibility for safeguarding its nuclear exports to non-European countries. The fact that the Soviets gave full support to the IAEA safeguards system in 1963 also leveled debates. From 1965 to 1967, the IAEA was able to review its safeguard system and establish a more rigorous one covering reactors of all sizes, reprocessing plants, and fuel fabrication plants. A major turning point was the 1968 Treaty on Non-Proliferation of Nuclear Weapons (NPT) that allowed the application of safeguards to all the nuclear material in the states that had not acquired nuclear weapons. The treaty entered into force in 1970 and the Board of Governors approved the IAEA safeguards system a year later. Although limited, the safeguards system focused on nuclear sites that each member state declared as such and willingly placed under the IAEA inspection. The possibility that undeclared plants might exist remained, but the IAEA safeguards had no power to inspect them. The architects of the system assumed that clandestine nuclear programs and undeclared plants would be detected by other means. It took them two decades to realize that only a stronger safeguards system had the chance to unmask illicit nuclear activities.

Transforming Safeguards

As David Donohue argues, “For the international community, the summer of 1991 was a turning point of scientific discovery, one that set the stage for stronger nuclear safeguards.” He continues, “IAEA and United Nations and inspectors were combining the rubble of Iraq’s nuclear installations looking for evidence for a secret program to produce atomic bombs, something expressively forbade by Iraq’s ratification of the Treaty on the Non-Proliferation of Nuclear Weapons (NTP).”³⁹

Chief Inspector Demetrius Perricos headed the first team that landed in Baghdad. Despite their persistent attempts, inspectors were not able to find any evidence of a nuclear weapons program. According to Leslie Thorne, a member of the team, the sites were stripped of equipment and the Iraqis did not facilitate the inspection in any way. Subsequent intelligent information after the first visit proved that Iraqis uncovered and removed buried disc-shaped objects from their previously major nuclear research site. The interesting piece in this story is that, during its second inspection mission, the IAEA team decided to follow a more aggressive strategy. Giving no warning on where the inspection was going to take place, the team appeared one day at the gates of a large military camp. Admission was refused. “While this was going on,” Thorne explained, “two members of the team climbed to the top of a nearby water tower and spotted a convoy moving off through a rear exit. Two other team members drove off at high speed to intercept the convoy. This was not simple since the convoy was several miles away and the only way to bypass the camp was by a tortuous route through local village markets

³⁶ On the diplomatic background to Euratom see John Krige, *Sharing Knowledge, Shaping Europe: US Technological Collaboration and Nonproliferation* (Cambridge, MA: MIT Press, 2016).

³⁷ H. L. Nieburg, “Atoms for Peace: Hopes Deferred,” *Bulletin of the Atomic Scientists* 20, no. 1 (1964): 35–40.

³⁸ *Ibid.*, 38.

³⁹ Donohue, “Key Tools for Nuclear Inspections” (ref. 3).

and cutting onto a motorway.” The trucks were loaded with the missing equipment and “the evidence was obtained.”⁴⁰

In retrospect, as Mohamed ElBaradei argues, “far from encouraging cooperation in Iraq, the inspector’s invasive ‘cowboy’ behavior naturally caused a buildup of resentment on the part of the Iraqi’s, particularly since these arbitrary intrusions never yielded any results.” It was around that time when David Kay, a political scientist from the United States and former mid-level manager in the IAEA’s Technical Cooperation Program, was assigned as safeguards inspector and joined the Iraq mission. According to ElBaradei, Kay and his fellow Americans established a culture that was foreign to the IAEA inspections. The predominantly American nuclear inspection team in Iraq was highly qualified in technical matters. Most of the scientists were coming from the top US national laboratories but “had no clue how to conduct international inspections or, for that matter, about the nuances of how to behave in different cultures.”⁴¹ Trained as technical experts and being qualified scientists, international diplomacy was definitely not their strength.

IAEA inspectors were allowed to collect conventional samples from the Iraqi sites under investigation. “Inspectors innovated,” an IAEA representative explained. “They used cotton towels to ‘swipe’ items from the damaged facility to check whether there were any traces of the kind of elements used in the facility prior to its destruction. An entire spectrum of uranium—from depleted to highly enriched—was identified.”⁴² The contaminated towels were sent to Vienna and analyzed with the use of glove boxes at the safeguards laboratory. Through this process, glove boxes were turned into a major instrument of IAEA’s international policy and diplomatic negotiations and into an emblem of scientific authority assuring the agency’s credibility.

As a next step, and in between the second and third inspection, IAEA Director General Hans Blix visited Baghdad trying to persuade the government to make a full declaration of its uranium enrichment program. Under the pressure of the international community and further developments based on information received from intelligence sources, the Iraqi authorities presented a detailed list of relevant equipment and its location. It became obvious that uranium enrichment and reprocessing activities for plutonium separation were among Iraq’s clandestine activities.⁴³

Finally, on November 15 and 17, 1991, the IAEA team removed from Iraq all the strategically most significant material, leaving behind 400 grams of irradiated high-enriched uranium. On the top of the diplomatic and political entanglements, a practical problem emerged: no fuel handling organization was willing to sign a contract to remove the fuel from Iraq, given the legal and safety issues

at hand. Only later did a commercial consortium from two member states enter contract negotiations that lasted several months.⁴⁴

Aside from removing all nuclear material from Iraq, the UN Security Council devolved the IAEA to destroy all significant equipment as well. According to the IAEA plan, priority was given to the Electromagnetic Isotope Separation (EMIS) equipment, whose destruction involved cutting the magnetic pole pieces, the vacuum chambers, and all associated equipment. In addition, they destroyed hot cells and glove boxes on the Tuwaitha Nuclear Center. A nuclear complex south of Baghdad, Tuwaitha was equipped with hot cells and glove boxes for handling radioactive material. The first extraction cycle of nuclear repossessing, a highly active cycle, took place in hot cells, chambers equipped with tongs for remotely handling highly radioactive material. The second cycle, a lower radiation process, was done in glove boxes. During the seventh inspection, the IAEA team destroyed the hot cells by cutting the manipulator arms and control wires. To ensure that no further use of the glove boxes could be possible, inspectors poured cement into them (Figure 3).

In the aftermath of the unmasking of Iraq’s clandestine nuclear program, critical questions arose. Why over the years—Iraq had begun the program as early as 1982 shortly after Israel’s bombing of Iraq’s research reactor at Osirak, south of Baghdad—had the IAEA missed this undeclared nuclear program? The need for additional legal and oversight authority, in short, a stronger safeguards system, became obvious to the IAEA. “The deliberate deception carried out by Iraq had made clear that conducting international safeguards by ‘honor code’ was no longer adequate,” admitted ElBaradei, “nor was it enough to inspect only what a country declared; nor was IAEA authority sufficient.”⁴⁵

IAEA’s experience with Iraq revealed a serious shortcoming of the safeguard system. Throughout the 1980s, IAEA experts, based on the existing safeguards system, had the right to inspect those facilities that Iraq had declared them to the IAEA and they were therefore officially under its regulatory jurisdiction. They missed those that had been secretly developed for the production of nuclear weapons. As Deputy Director General of Safeguards Bruno Pellaud stressed, “The effectiveness of the IAEA safeguards system depends on what the agency knows about nuclear-related activities. With a broad knowledge of such activities and a good understanding of their relationships, the IAEA can with a fair degree of confidence assess the non-proliferation credentials of a country.” So instead of “piling up controls vertically on existing nuclear facilities” the IAEA was aiming to “broaden its horizontal view.”⁴⁶

The safeguards system needed to become stricter in order to reduce the risk that other states might develop clandestine nuclear programs. Technology was called on to play a crucial role in this change of worldview. But as Pellaud explained, the IAEA was not planning to install

⁴⁰ Leslie Thorne, “IAEA Nuclear Inspections in Iraq,” *IAEA Bulletin* 1 (1992): 16–24, on 20.

⁴¹ Mohamed ElBaradei, *The Age of Deception: Nuclear Diplomacy in Treacherous Times* (New York: Metropolitan Books, 2011), 14–15.

⁴² Aabha Dixit, “Swipe Check: Collecting and Analyzing Environmental Samples for Nuclear Verification,” *IAEA News Release*, January 19, 2016, <https://www.iaea.org/newscenter/news/swipe-check-collecting-and-analysing-environmental-samples-nuclear-verification>.

⁴³ For a detailed description of the IAEA inspections and related documents see INVO and Iraq Chronology: <https://www.iaea.org/OurWork/SV/Invo/chronology.html>.

⁴⁴ United Nations Security Council, S/23295, December 17, 1991.

⁴⁵ ElBaradei, *Age of Deception* (ref. 41), 28.

⁴⁶ Bruno Pellaud, “Safeguards: The Evolving Picture,” *IAEA Bulletin*, 4, no. 2 (1996): 2–6.



Figure 3. Under supervision of the IAEA team, Iraqi workers pour concrete into glove boxes so they can no longer be used for proscribed activities at Tuwaitha, October 1991, 7th United Nations inspection in Iraq. (Courtesy of the Archives of the International Atomic Energy Agency, no. 4954).

traditional safeguards equipment for nuclear materials. Inspectors were supposed to walk freely around for visual observations. When they judged it appropriate, they should be allowed to take an environmental swipe sample. What was now distinctive was that the analysis did not take place at the site. Instead, the IAEA primarily assessed such information in its own facilities and, when necessary, asked questions to check its consistency. This is known as “environmental sampling for safeguards” or ESS. The IAEA developed what is called the “Clean Laboratory,” part of the Safeguards Nuclear Material Laboratory. By 1995 the IAEA had put in place a new safeguards agreement guided by a totally different philosophy.

As a result, on May 13, 1997, the IAEA Board of Governors adopted the Model Additional Protocol, a legal instrument and a milestone in the agency’s history that had the potential to strengthen the effectiveness of the NPT safeguards system. The collection of environmental samples from the sites under inspection—and the technology for analyzing them—became central for the agency to assure the absence of any undeclared nuclear material and activities.⁴⁷

Yet, ten year later, in 2007, it had become obvious that the agency’s safeguards laboratory did not meet the UN safety requirements because of its aging technical infrastructure and analytical equipment. The Board of Governors was informed that the ability of the Safeguards Analytical Laboratories, known as SAL at the time, to provide independent and timely analysis of nuclear samples collected by the safeguards inspectors was indeed at risk. An international workshop held in 2006 and a follow-up study group of internal IAEA experts verified the need to renovate the existing facilities and brought up the wider issue of the construction of new laboratory space. The recommendations stirred a heated discussion among the delegates who met in Vienna on November 23, 2007, to discuss “sustaining credible safeguards.”

The issue at hand was whether the IAEA ought to perform all sample analysis in its own laboratories or share it among a network of verified national safeguards laboratories. As Eldin Elamin, Sudan’s delegate representing the Group 77—a loose coalition of developing countries at the United Nations that acted together in order to increase their negotiating capacity within the UN agencies—and China argued, independence of the agency’s statutory activities was a precondition for its credibility. But instead of arguing for the renovation of the agency’s laboratories,

⁴⁷ IAEA Model Additional Protocol, INFCIRC/540, 1997, <https://www.iaea.org/safeguards/safeguards-legal-framework/additional-protocol>.

Elamin favored the development of such laboratory facilities in IAEA member states so as to share SAL's work burden. The Portuguese ambassador Joaquim Duarte, speaking on behalf of the European Union, instead favored the modernization plan so as the agency could perform analyses in a "cost-effective, accurate, confidential, and timely manner."⁴⁸ Duarte had an additional reason to align with the agency. Two months earlier Mohamed ElBaradei walked out on Duarte, who then represented the EU, during his speech as a protest because Duarte did not fully support ElBaradei's deal for new inspections in Iran. It was now Duarte's chance to offer the diplomatic backing ElBaradei had expected on a different issue a couple of months earlier. In an interesting intersection of nuclear science and diplomacy, the Director General underlined the fact that the issue opened up Pandora's box. The question was what kind of agency the member states wished to have in the years to come.

After much diplomatic maneuvering, in 2010 the Board of Governors approved and signed the contract for the construction of a new laboratory for the analysis of nuclear material samples, known now as the Safeguards Nuclear Material Laboratory, or NML. The decision was based on the IAEA's ambitious plan to address key international security concerns in an independent way. In 2012, the fifty-sixth regular session of the General Conference, the highest policy-making body of the IAEA, urged the Secretariat to develop a strategic overarching plan of action for the modernization of the laboratory at Seibersdorf and invited the member states to support the project financially. Indeed, the modernization plan was generously supported by individual member states and the European Union and included, among other renovations, new laboratory buildings to host the NML. At the time, the Deputy Director General Herman Nackaerts argued that the new NML building would "provide reliable, expandable, flexible work spaces for staff conducting analytical work at Seibersdorf—and do so within a coherent, safe, and secure Agency complex."⁴⁹ Since then, the agency's safeguards system has been radically strengthened by improving, not only its legal and political mechanisms, but also by modernizing its laboratories. This is why, in 2014, the IAEA trumpeted the installation of the new glove boxes along with the renovation of the Safeguards Nuclear Material Laboratory.

Why Glove Boxes Matter

Science and technology studies scholars have shown that boxes, although ordinary objects, define their content and by so doing produce knowledge about it. Especially in laboratory studies, boxes and all kinds of containers classify, tag, preserve, transport, and organize knowledge in a

pervasive way.⁵⁰ As routine material objects, I find boxes—glove boxes in this case—playing an additional yet unappreciated role. They define and contain the activities of international organization and work as signs of multiple transformations. They help the transformation of nuclear materials into parts of nuclear weapons, provide evidence of certain nuclear activities (authorized or not), guide international nuclear policies, generate classified reports, frame political arguments. Scientific knowledge meets politics inside a glove box. In the early days, glove boxes allowed non-scientists to manipulate hazardous materials and participate in industrial production of nuclear weapons. Although often claimed otherwise, they proved to be hazardous, raising questions about institutional radiation protection efforts. Gradually they became the emblem of nuclear safety in US national laboratories, nuclear industries, and nuclear international organizations such as the IAEA.

Since its establishment, the IAEA has emerged as a powerful political, international organization closely connected to the United Nations. Its member states are supposed to comply with IAEA's guidelines and directives in key issues such as nuclear non-proliferation, safety, and health. The end of the Cold War in the early 1990s transformed the global geopolitical map, allowing the IAEA to play an even more powerful role in nuclear politics. But what really affected the IAEA policies regarding safeguards was the Iraqi crisis. At the turn of the twenty-first century, public understanding of the IAEA's role as nuclear watchdog—often a biased one—was well established. Shifting its emphasis from promoting peaceful uses of atomic energy to guarding nuclear security, the IAEA has been perceived as irreplaceable in fostering nuclear security worldwide. At the same time, its credibility has been often questioned. Not by chance did Director General Yukiya Amano argue against this view in the Sustainable Development Summit in New York in 2015. "The IAEA delivers. We are much more than just the world's nuclear watchdog."⁵¹ A year later, at the Nuclear Industry Summit in Washington, DC, Amano clearly described the agency's role: "We provide guidance covering key aspects of nuclear security. We help to make borders more secure by installing radiation monitors at ports and border crossings. We help countries to improve physical protection at nuclear installations and hospitals, so that radioactive material is not stolen. We provide training and equipment to law

⁴⁸ Board of Governors, General Conference GOV/OR.1199, November 23, 2007. China never joined Group 77, but supported it in several occasions.

⁴⁹ Board of Governors, General Conference, GOV/INF/2013/11-GC(57)/INF/11, August 29, 2013; Board of Governors, GOV/OR.1199, November 23, 2007; Board of Governors, General Conference, GOV/INF/2013/11-GC(57)/INF/11, 2 August 29, 2013; General Conference GC(56)/RES/12.5., September 2012; "Senior European Officials Visit IAEA Labs in Seibersdorf," *IAEA News Release*, May 15, 2013, <https://www.iaea.org/newscenter/news/senior-european-officials-visit-iaea-labs-seibersdorf>; "The IAEA Reviews its Trust to JACOMEX," <http://www.jacomex.fr/en/all-news/news/detail/the-iaea-renews-its-trust-to-jacomex/>.

⁵⁰ See for example, Alexander Klose, *The Container Principle: How a Box Changes the Way We Think* (Cambridge, MA: MIT Press, 2015); Maria Rentetzi, "Packaging Radium, Selling Science: Boxes, Bottles, and Other Mundane Things in the World of Science," *Annals of Science* 68, no. 3 (2011): 375–99; "The Box: Commonplace Artifacts in the Production of Scientific Knowledge," *Backchannels*, April 18, 2016, http://www.4sonline.org/blog/post/the_box_commonplace_artifacts_in_the_production_of_scientific_knowledge; Maria Rentetzi, "From Pyxis to Box: An Hymn to Pandora" in *Boxes: A Fieldguide* Susanne Bauer, Martina Schlünder, Maria Rentetzi (eds) (Manchester: Mattering Press, 2017); Anke te Heesen, *The World in a Box* (Chicago: University of Chicago Press, 2002); Sherry Turkle, *Evocative Objects: Things We Think With* (Cambridge, MA: MIT Press, 2011); *The Inner History of Devices* (Cambridge, MA: MIT Press, 2011); *Falling for Science: Objects in Mind* (Cambridge, MA: MIT Press, 2011).

⁵¹ Miklos Gaspar, "IAEA 'much more than just the world's nuclear watchdog': >Director General at Sustainable Development Summit," *IAEA Press Release*, September 29, 2015, <https://www.iaea.org/newscenter/news/iaea-much-more-than-just-the-worlds-nuclear-watchdog-director-general-at-sustainable-development-summit>.

enforcement personnel to help them identify and intercept illicit trafficking in nuclear and other radioactive material.”⁵²

The understanding of the IAEA as the global platform for nuclear security efforts gave rise to the transformation of glove boxes from routine laboratory devices for radiation protection to key technologies for ensuring nuclear security. The case of Iraq illustrated the shift. Glove boxes were used to protect analysts working at IAEA’s safeguard laboratory with samples of materials and swipes of dust that IAEA inspectors took from within and near a number of nuclear facilities in Iraq. Glove boxes were also used to protect Iraqi scientists who worked on the country’s clandestine nuclear program and separated plutonium. Their destruction was understood as a critical step in undermining Iraq’s nuclear capabilities. Glove boxes acquired a symbolic significance to a newly redefined agency as it moved into the twenty-first century. They served as indications of the agency’s ability to detect unauthorized nuclear programs and signs of deception, build rationale for military invasion, and eventually to enforce of the Non-

Proliferation Treaty within UN member states. The picture of Gabriele Voigt and Vadimir Sucha in front of the newly delivered glove boxes to the IAEA now makes more sense. As Sucha declared: “The IAEA laboratories have to be world class. The international community relies on the conclusions of the IAEA Department of Safeguards concerning the non-diversion of nuclear material, and we have to give the IAEA the tools it needs to do the job.”⁵³

Acknowledgments

This work was supported by a Lise Meitner Fellowship from the Austrian Science Fund (FWF): project number M 1727 – G16. A version of this paper was presented at the annual meeting of the Society for Social Studies of Science in Denver, 11–14 November 2015. I would like to thank Richard Rich for his insightful comments and editorial help as well as the two Endeavor referees for their crucial suggestions. Joseph Martin was instrumental in helping me shape the paper and clarify my argument. To Crissy Willson from the American Glove Box Society I am thankful for sharing several of the Society’s older newsletters. I am also indebted to the University of Vienna, Institute for Philosophy, and especially to Professor Martin Kusch, for their general support of my overall project on the history of the International Atomic Energy Agency and its dosimetry projects.

⁵² Aabha Dixit, “IAEA Plays Central Role in Global Efforts to Strengthen Nuclear Security, Says IAEA Director General,” *IAEA Press Release*, March 30, 2016, <https://www.iaea.org/newscenter/news/iaea-plays-central-role-in-global-efforts-to-strengthen-nuclear-security-says-iaea-director-general>.

⁵³ Scheland, “Nuclear Material Laboratory” (ref. 2).