EMPIRE OF CALAMITY:

MAKING PLUTONIUM IN STALIN'S RUSSIA

An NCEEER Working Paper by

Kate Brown
University of Maryland, Baltimore County

National Council for Eurasian and East European Research
University of Washington
Box 353650
Seattle, WA 98195
info@nceeer.org
http://www.nceeer.org/

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Executive Summary

The official history of the Maiak plutonium plant in the Southern Urals records three accidents during four decades of operation. In reality, however, accidents trailed Soviet plutonium production like a loyal dog, from the very first day of operation. Saving money, plant leaders cut corners on training, facilities, worker safety and radiation monitoring. Worried about secrecy, security officials forced workers to memorize complicated blueprints and procedures and remain in ignorance about the harmful properties of the radioactive substances with which they worked. On a shoe-string budget, plant operators rushed to produce the first bomb cores to end the American nuclear monopoly. In so doing, they produced a nuclear catastrophe more deadly than a Hiroshima-style attack.

Soviet propagandists used to plaster a slogan on the side of buildings: “Cadres make the difference.” If this tired mantra is true, it begs a number of questions. What came of building the first Soviet plutonium plant with workers who were incarcerated, legally and physically, behind the city’s barbed wire? How do you guard a project on a pass system with illiterate guards who cannot read passes? What of staffing technically-advanced factories with chemists who got their degrees from culinary schools or a senior engineer who repaired expensive machinery with a sledge hammer? [1] And how do workers perform while rushing, the bosses demanding, the security staff threatening, living in crowded barracks and sleeping irregularly?

The answer to these many questions is singular—calamity. The official history of the Maiak plutonium plant in the Southern Urals records three accidents during four decades of operation.[2] In reality, however, accidents trailed Soviet plutonium production like a loyal dog, from the very first day of operation.

In June 1948, as the evening solstice sun gilded a tall, handsome building on a tree-lined lane, Igor Kurchatov sat inside, in the control room of the first Soviet production reactor A, or “Annushka,” as it was lovingly called. Finally, one year behind schedule, on June 10, Kurchatov pulled the switch that lifted the control rods out of the reactor face.[3] The men cheered at seeing the darting wattage indicators. For the scientists, the glowing dials illuminated the path to the Soviet “nuclear shield.” For the rest of the world, when they learned of it, these were the first lights of the costly Soviet-American arms race. For posterity, the hum of Annushka’s turbines heralded a rushing new geyser of radioactive isotopes which spilled forth from the fusion of

[1] On problems of ill-educated workers and the need for literacy classes, see “Zasedanie partiinogo aktiva: o vypolnenii meropriiatii po uluchsheniiu raboty s kadramim” 6 July 1951, OGAChO P-1137/1/31: 162-168.

[2] Vladislav Larin, *Kombinat "Maiak": Polveka problem* (Moscow, 1996): 47.

[3] The original start up date was set for the second quarter of 1947. See "Protokol no. 17 zasedaniia spetsial'nogo komiteta pre sovnarkome SSSR," 25 March 1946, in Riabev, *Atomnyi proekt SSSR,* Vol II, bk *2:* 83-85. For Kurchatov’s description of the start-up, see "Dokladnaia zapiska I. V. Kurchatova o puskovom oprobovanii promyshlennogo uran-grafitnogo reactora," 4 July 1948, in Riabev, *Atomnyi proekt SSSR,* Vol II, bk 4: 451-456.

nuclear technology hitched to endemic Soviet poverty.

On June 19, the reactor was fully loaded and Kurchatov, later admitting he was in a hurry, gave the order to operate at full power without any further tests.[4] That evening, Kurchatov called Beria to report his success, but the call was premature. Annushka ran for less than twenty-four hours when an operator noticed that water pouring from the reactor was radiated at thirty times higher than the permissible level. Apparently, cooling water levels had dropped too low in several canals, causing uranium fuel slugs to overheat, rupture and leak radioactive steam. Fearing an explosion, Kurchatov dropped the long, thin control rods back into the graphite reactor buried in the floor, an exaggerated act of technological fornication, and tried to figure out how to clear out the slugs gummed with graphite. He called Beria to tell him the bad news. Tersely, Beria asked how long it would take to start back up.

For the next three weeks the scientists fretted over how to fix the ruptured slugs and clear the canals. They worked on the problem around the clock, all the while the irradiated uranium emitted radioactive isotopes which sent out harmful gamma rays. No amount of cleaning arrested the needle on the Geiger counter. Crews scrubbed, brushed and finally pulled up the linoleum in the control room only to find the new tiles immediately contaminated. They eventually installed a stainless steel floor, which stayed clean, but walls, clothes, shoes, and the workers themselves still registered.

Beria was not concerned about workers' health. In general, the leaders of the atomic project displayed a cavalier attitude toward the dangers of radiation. During Annushka's first accident, General Zaveniagin arrived to oversee the clean-up. He sat on a stool in the reactor hall in his street clothes, pulled a mandarin out of his pocket and ate it. The plant director, Boris

[4] "Dokladnaia zapiska I. V. Kurchatova o puskovom oprobovanii promyshlennogo uran-grafitnogo reactora," 4 July 1948, in L. D. Riabev, ed. *Atomnyi proekt SSSR: Dokumenty i materialy,* Vol II, bk 4 (Moscow: Fizmatlit, 2004): 451-456.

Muzrukov, stood alongside him. Later dosimetry readings of Muzrukov's house registered ten times greater than the permissible norm.[5] In June 1948, Tkachenko penned this worried denunciation of Kurchatov: "Academic I. V. Kurchatov at times ignores all rules of safety and precaution (especially when something goes wrong). He personally goes into the premises where the activity is exceptionally higher than the acceptable norm. Comrade E. P. Slaskii behaves even more carelessly."[6] Kurchatov, Tkachenko continued, descended into the reactor chamber with the alarm going, radiation 150 times higher than permissible, his body guards unable to stop him.

Beria, however, kept the pressure on for results, ignoring safety concerns, and in mid-July Kurchatov again had the reactor started up at full power, though the problem of fractured fuel slugs remained.[7] Ten days later, more slugs in the reactor blistered and burst, provoking another crisis and more telegrams to Moscow. This time, however, Kurchatov kept the ailing reactor going. The men called the cracked and radiating fuel cells "goats," and with this household slang they assimilated the 'emergency situation' and domesticated its dangers into their daily working order.[8] Kurchatov ran the leaking reactor until January 1949, by which time Soviet scientists estimated they had enough plutonium for exactly one bomb, and only then did Kurchatov shut Annushka down. Engineers calculated they needed a year to dismantle the broken reactor and repair it. Beria gave them two months.

The staff had to decide how to get to the damaged fuel cells out of the reactor. If the

[5] Larin, *Kombinat, Maiak:* 77.

[6] Tkachenko Beria, 24 June 1948 in Vladimir Gubarev, *Belyi arkhipelag Stalina: Dokumental'noe povestvovanie o sozdanii iadernoi bomby, osnovannoe na rassekrechennykh materialakh "atomnogo proekta SSSR* (Moskva: Molodaia gvardiia, 2004), 302-303.

[7] "Pis'mo Beria, Malenkova, Voznesenskogo, Vannikova, Pervukhina, Zaveniagina i Makhneva Stalin," no later than 25 July 48, in Riabev, *Atomnyi proekt SSSR,* Vol II, bk 4: 459-450.

[8] "VCh-gramma Vannikova, Kurchatova, Muzrukova v adres Pervukhina ob avarii na agregate "A"," 26 July 1948, 461-462 in Riabev, *Atomnyi proekt SSSR,* Vol II, bk 4: 461-462. Novoselov and Tolstikov *Taina "Sorokovki":* 149-153.

reactor was working normally, they would have dropped the irradiated slugs into a pool below the reactor where the slugs would cool. But the Soviet Union's entire stockpile of uranium had been loaded into Annushka. If operators dropped all the slugs in the pool, they would lose the good slugs with the bad, and have no fuel with which to reload the reactor to produce more plutonium for a second and third bomb. Rather than waste the precious uranium, Beria and Vannikov ordered workers to unload the reactor by hand, sorting the cracked slugs from the undamaged ones, which would be reloaded into the reactor.[9]

It is hard to imagine what it meant to gather the courage to enter the central hall of a reactor, where thousands of curies of radioactive isotopes were decaying, and pull irradiated slugs from the reactor face by hand. Everyone took their turn—prisoners, deportees, soldiers, hired workers, supervisors, scientists.[10] They were given a cleansing glass of vodka afterward, while fighting back a strange dizzy, sick feeling. Kurchatov too, reportedly, snatched a gas mask and ran in.

In the first 34 days of 1949, Kurchatov and his staff unloaded and reloaded 39,000 irradiated uranium slugs. Hundreds of men got sick with nausea and nose bleeds followed by intense pain and knee-buckling fatigue. At the time, the official tolerance dose for a year was 30 rem. Cleaning up Annushka, workers received doses from 100-400 rems.[11] Four-hundred rems is enough, not to kill immediately, but to contract early "radiation" aging which leads to chronic exhaustion, painful joints, crumbling bones, and ended in lung and bone cancers, and diseases of the heart and liver.

[9] Sergei Parfenov, "Kaskad zamedlennogo deistviia," *Ural* 8, no. 3 (2006); and Aleksei Mitiunin, "Natsional'nye osobennosti likvidatsii radiastionnykh avarii," *Nezavisimaia gazeta*, 15 April 2005.

[10] Ibid, and Aleksei Mitiunin, "Natsional'nye osobennosti likvidatsii radiastionnykh avarii," *Nezavisimaia gazeta*, 15 April 2005.

[11] Parfenov, "Kaskad.

After sorting, the first batch of irradiated uranium was cooled underwater. Plant engineers knew that it was best to cool the slugs for 120 days to reduce by a thousand times radioactive iodine and other short-lived, harmful isotopes. Plant leaders, rushing, however, abbreviated the cooling time to 30 days, and processed "green," or highly-radioactive, fuel.[12] They built 150 meter smokestacks to channel the radioactive gases high into the atmosphere. They hoped that the poisonous gases mixing with fresh air would diffuse the contaminants safely over a large territory. The winds directed the contaminants in a path shaped like an arrow in mostly an eastward direction over fields, pastures, lakes, swamps and streams.[13]

After cooling, the irradiated slugs were ready for processing, and went to Area B to be dissolved in nitric acid, the resulting toxic cocktail distilled to separate out plutonium. But there was a kink here too. The new processing plant, Factory No. 25, was not yet ready. The engineers were still working out the plant's design and equipping it. Faina Kuznetsova, an original lab technician, remembered how security officers pressured her supervisor to finish faster. They posted a guard, took his pass and told him he must remain at the factory until his division was equipped for start-up. "What could he do alone?" Kuznetsova recalled, "Of course, we all stayed to help." For twelve days and nights the staff of division no. 8 remained at the factory hurrying to finish.[14]

Plant employees were mostly young women, girls really, right out of school. Their supervisors were generally men.[15] The chemical industry in the USSR before WWII had largely

[12] Ia. P. Dokuchaev, "Ot plutoniia k plutonievoi bombe: iz vospominanii uchastnikia sobytii" *Istoriia Sovetskogo atomnogo proekta:* 291.

[13] Larin points out that evidence of the volume of gaseous waste emitted from Reactor A processing green fuel is published "no where in the world." See *Maiak, PPA*: 27-28.

[14] Larin, 2001: 87-88.

[15] In coming up with formulas for chemical separations, several female scientists worked on the problem, but male scientists were shown the critical intelligence documents on American processing methods. "Pis'mo I. V. Kurchatova M.

been neglected, a field left for women to study.[16] In Ozersk, men ruled over the realm of physics and reactors because reactors were considered dangerous. Reactors issued gamma rays strong enough to penetrate skin and directly irradiate a person's vital organs. The relationship between gamma rays and health was direct. A strong gamma dose and a person immediately felt unwell. A bigger dose, and Soviet researchers learned, lab mice, rats, and dogs died.[17] In the late forties, Soviet bio-physicists thought the workers in chemical processing were safe because plutonium and many long-lived radioactive by-products do not give off gamma rays, but far weaker alpha and beta rays which cannot penetrate skin. It took several years for Soviet researchers to consider the harmful effects of ingesting radioactive substances. As a consequence, Soviet scientists figured that the chemical processing of plutonium solutions was safe enough work for women.[18]

Meanwhile, the young women made good workers. They had usually worked in chemical factories during the war. Because men their age were fighting, many had reached their mid-twenties without marrying. Many would never marry. They had come of age in a wartime labor climate where to arrive at work just twenty minutes late was a crime. They were disciplined, accurate and responsible.[19] Men, at any rate, were in short supply. The Soviet Union took a vast demographic blow during WWII. Eight million mostly male soldiers died in the war. While men fought and died, young women had taken their places in university science labs. These young chemists moved to Ozersk to oversee the working girls as they processed irradiated uranium into

G. Pervukhinu ob oznakomlenii s materiaiami Biuro no 2 B A Nikitina, A P Ratnera i B S Dzhelopova," 9 April 1946 in Riabev, *Atomnyi proekt SSSR,* Vol II, bk 4: 425.

16 Pap A. Ndiaye, *Nylon and Bombs: DuPont and the March of Modern America* (Baltimore: Johns Hopkins University Press, 2007), 173.

17 Vladimir Gubarev, "Glavnii ob'ekt derzhavy: po stranitsam "Atomnogo proekta SSSR,"" *Vsiakaia vsiachina: bibliotechka raznykh statei*, 2010, May 2010 <http://wsyachina.com/index.html>.

18 Sokhina, *Plutonii v devichikh rukakh*: 40-42. Gus'kova testified that they understood the effects of internal ingestion of radiation only in research conducted from 1953-1957. Gus'kova, 2004: 101.

19 Nikolai Rabotnov, "Publitsistika--Sorokovka," *Znamia* July 1 (2000): 165.

plutonium.[20]

In December 1948, the new, specially-built plutonium processing Factory No. 25 was ready. It was a curious affair. Soviet designers had sought to hide the factory from aerial detection, so rather than copy the design of the massive stadium-sized cement brick that was T-Plant at Hanford, they built the plant vertically to make a smaller footprint. As a consequence, the processing chambers were stacked on top of one another with pipes flushing radioactive solutions and vents with radioactive gases running up walls and across ceilings. These design features meant that if leaks or spills occurred in one area, solutions could drip down to work stations below, expansively spreading contamination.

And there were a lot of spills, starting with the day the plant opened. On that day, a crowd of scientists, security and military men gathered into the final chamber waiting to see the first plutonium solution emerge from the vast still. A young engineer Zoya Zverkova supervised the shift. At the appointed time, nothing filtered out. They waited longer, the scientists nervously discussing the technical processes, the generals behind them menacing, Zverkova checking and re-checking the instruments. Everyone knew in those years that failures were the results, not of accident or miscalculation, but of enemies and saboteurs. Finally someone noticed a yellow pulp dripping from a vent in the ceiling onto the men in street clothes. Investigating, they found that the plutonium solution had bubbled into a foam and been sucked out of the production cycle and into the factory's ventilation system. In sub-zero temperatures, workers climbed to the fans on the roof and scraped up the precious radioactive residues. The scientists made changes, ran the process again and were happy to see the plutonium precipitates drip into the filter. Checking its

[20] *Plutonii v devichikh rukakh.*

composition, however, they found the solution held no plutonium.[21] Instead, plutonium was everywhere else, inside of chambers, vents, equipment, vessels, the control room, on the rubber galoshes of the generals. Finally, a third bath landed plutonium. In the meantime, inside the plant, where the ventilation ducts and pipes lead everywhere, so too followed plutonium and radioactive waste.[22]

Running through the plant was a large, cement-lined 'canyon,' in which radioactive solutions were to move from chamber to chamber along remote-control conveyor belts. When the plant was built, the canyon was sealed off with massive 'stones,' huge cement safety doors, which were supposed to remain in place after start up because the canyon was highly radioactive. The canyon was designed to be an eternal tomb for the dangerous isotopes within. Soviet engineers, however, did not know how to produce metals that could withstand the heat and corrosive qualities of radioactive solutions. They plated beakers, cups, and equipment with gold, silver and platinum, hoping they would hold up to radioactive toxins. But the precious metals, as well as rubber stoppers and gaskets, gave way to the powerful heat, alpha particles, and severe temperature changes of the radioactive solutions.[23] A month after start up, a pipe containing plutonium solutions developed a hole and leaked onto guards at a door. Later, other leaks sprang throughout the plant.[24]

Many spills occurred inside the sealed-off canyon. Since the spills contained valuable

[21] L. P. Sokhina, "Trudnosti puskogovo perioda pre osvoenii technologii polucheniia metallicheskogo plutoniia vysokoi chistoty v period 1949-1950 gg.," in L. D. Riabev E. P. Velikhov, N. A Chernoplekov, Iu V Gaponov, ed. *Nauka i obshchestvo, istoriia Sovetskogo atomnogo proekta (40e-50-e gody) (*Moscow: Izdat, 1997): 138, and Novoselov and Tolstikov, *Taina Sorokovki:* 160.

[22] Larin, 2001: 83 and Novoselov and Tolstikov, *Taina "sorokovki*": 160.

[23] My thanks to Harry Winsor for his help with the corrosive qualities of plutonium processing solutions. For Soviet attempts to try to 'battle against corrosion,' see ""Postanovlenie SM SSSR no 16909-rs ob organizatsii na zavode no 92 laboratorii po bor'be s korroziei," 25 October 1949, in L. D. Riabev, ed. *Atomnyi proekt SSSR: Dokumenty i materialy*, Vol II, bk 4. (Moscow: Fizmatlit, 2004): 338-339.

[24] Larin, "Mayak's Walking Wounded:" 23.

plutonium, the bosses demanded staff sop up the solutions. Clean up crews were not allowed into the plant, for secrecy's sake, so technicians managed the spills themselves. Entering the canyon violated the most basic safety regulations, but workers rolled the stones aside anyway, descending into the highly-radioactive canyon. Once the stones were pushed aside, they stayed that way. "Everyone went into the canyon many times," Faina Kuznetsova remembered. "It seems strange now, but no one had planned for cleaning up spills. There was no method to safely collect spilled solutions. We had only washcloths, buckets, and sometimes rubber gloves. Some didn't have gloves and they scrubbed and wrung with bare hands. We mopped up the spills and poured them into big glass bottles. It was a very expensive compound and we were expected to recover every drop. Our spills weren't too big, from 50 to a 100 liters. There were spills in the earlier stages of processing that lost as much as two to three tons of solutions. To collect those spills with wash cloths was impossible. Those were real disasters."[25] I. Dvoryankin described to a Russian journalist, Vladyslav Larin, what it was like. "We worked without any protection other than gas masks. One by one we climbed down to the canyons. When blood began pouring from our noses, we pulled on the ropes to be brought up. We received extremely high doses of radiation, but thanks to our work, the plant was not stopped."[26]

Why so many spills? Kuznetsova blamed the haste and the strict regime of secrecy and fear. Security officers oversaw the young workers and kept track of the valuable tools and final product. Young inexperienced scientists caught violating the rules or making mistakes were given from two to five years hard labor, which they had to carry out working construction at the

[25] Larin, 2001: 85-87. Author interview with Anna Miluitina, 21 June 2010, Kyshtym.
[26] Larin, 2001: 85-87.

factory.[27] Kuznetsova related: "When we were hired to work at Maiak, nobody knew what the conditions would be. We were not warned about the effects of radioactivity. We didn't even know what radioactivity was. That is why we handled the radioactive solutions. We were afraid only of the KGB. Everything was done under the personal control of L. P. Beria and his envoys and they would convict for any blunder. And so fear pushed people to take steps that led to accidents. On top of that we worked with very expensive equipment and chemicals. They kept a close watch over the machinery, the gold and silver lab vessels. They cared more about that equipment and the final product than they did about people." Kuznetsova remembered bitterly.[28] And then there was confusion and ignorance. Beria had taken note of how a common worker, David Greenglass, had access to technical documents at Los Alamos and had reproduced them to hand off to his Soviet handlers. He did not want Soviet employees walking off with plans and formulas in the Urals. As a consequence, there could be no charts, no schema, nothing that could be copied down. While training for operations, employees were required to memorize the complicated network of plumbing, electronics and machinery in their sector. They also had to commit to memory the procedures of their work day. Kuznetsova: "People were in a constant state of stress, fearful lest they forget something important. And frequently they did forget, especially in the first period. All of that was reflected in our work."[29]

After the process of separating plutonium from uranium, plutonium solutions were delivered to Area V, which was dedicated to transforming plutonium in liquid form into metal ingots, and finally into the achingly-desired, soft-ball-sized orbs of weapons-grade plutonium for

[27] Ia. P. Dokuchaev, "Ot plutoniia k plutonievoi bombe: iz vospominanii uchastnikia sobytii" *Istoriia Sovetskogo Atomnogo Proekta: Dokumenty, Vospominaniia, Issledovaniia*, ed. V. P. Vizgin (Moscow, 1998): 291.

[28] Vladyslav B. Larin, "Mayak's Walking Wounded," The Bulletin of the Atomic Scientists September/October 1999: 23. Larin, 2001: 87

[29] Larin, 2001. 87. On the frequency of accidents, see also Timonin, *Pis'ma iz zony*, 13.

a bomb core. In February 1949, the first flasks of plutonium concentrate were ready for final processing into metal, but the next step, the specially-designed chemical-metallurgical plant, was still under construction. Rather than delay, plant managers ordered construction workers to make over a couple of old navy warehouses in a nearby village to serve as make-shift processing plants.[30]

Shops numbers Four and Nine looked and worked just like any other chemical laboratory: wooden tables, glass cabinets, beakers, and stainless steel sinks. The mundane quality of the labs is alarming. At the workshops, mostly young women processed radioactive solutions by hand in vented cabinets or simply on tables. For lack of stools, lab technicians rested on wooden bins containing radioactive waste. They poured solutions from vat to beaker, beaker to test tube. They stirred the coagulated goo in platinum cups. They ground radioactive powders on high counters. They walked with solutions down hallways to burners and ovens to calcify, roast and dry them. They carried buckets of radioactive waste down the same halls, past toilets, canteens and offices. Though young, the twenty-something employees had known work since they were children, and they toiled as they were used to, as if at any factory or farm. It was one young man's job to carry glass flasks of just-radiated solutions from Factory no. 25 to Workshop no. 4. He put the flasks in a bucket and slopped them over. Waste brigade teams lugged barrels of radioactive solutions to the forest not far from the plant, and, treating it like any other waste, burned the coagulated gells. They stood over the fires, raked the coals, and tossed the ashes into shallow graves.[31] Staff members were not told they were working with radioactive solutions. They knew the elements only by coded number. The girls were given only the most basic

[30] L. P. Sokhina, "Trudnosti puskogovo perioda pre osvoenii technologii polucheniia metallicheskogo plutoniia vysokoi chistoty v period 1949-1950 gg.," in L. D. Riabev E. P. Velikhov, N. A Chernoplekov, Iu V Gaponov, ed. *Nauka i obshchestvo, istoriia Sovetskogo atomnogo proekta (40e-50-e gody) (*Moscow: Izdat, 1997): 139-140.

[31] Larin, 2001: 113.

instructions to stir, heat, and pour. The pale blue production manual was locked in a vault and only the supervisors with special permission had access to it.[32]

As at Factory no. 25, recovering spilled plutonium at the metallurgical workshops was taken to an extreme. Larisa Sokhina remembered how an assistant, Georgi Aleksandrov, was filtering plutonium from a solvent when a glass retort exploded. Aleksandrov's face was badly cut, and while his colleagues helped him rinse away the radioactive solvent, the supervisor, Filiptsev, walked in and cursed them out for their carelessness. He ordered his staff to mop up Aleksandrov's blood in order to recover the spilled plutonium. As the employees discussed Aleksandrov's accident, they figured plutonium isotopes had entered his bloodstream. What would happen to him? Sokhina: "We were not sure how the plutonium would affect Aleksandrov's health, and so we were very interested in his recovery. After six weeks, he left the hospital and we calmed down—plutonium was not so dangerous, we told each other. Several years later, however, he died at an early age."[33]

On another day a young technician was filtering plutonium from leftover waste. A scientist had advised the girls to pour solutions in the containers in small amounts. But the process was taking too long for Filiptsev, the same supervisor, and he told a woman to pour greater volumes of the congealed solution into large containers. She did. The solution blew up. The ventilated box burned. Radioactive contaminants flew across the room, covering the walls and ceiling with a green substance which dripped onto the heads of those in the lab. El'kinaia burned her hand. Some of the radioactive solution landed in the Filiptsev's eye and he was flown directly to Moscow to a special, new ward no. 6 set up for radiation-related maladies. The rest of the women were ordered to leave the room, and two chief chemists put on gas masks and set to

[32] Gladyshev, 92: 6.
[33] Sokhina, 2003: 97.

scraping and preserving the plutonium from the ceiling and walls. After a cosmetic renovation, the technicians returned to work in the contaminated room.[34]

There was little understanding of what an accident meant at a plutonium processing plant, so that petty rules trumped safety. Elena Sokhina described how one day in the lab she raised a glass of solution to her eye to stir the pulp within. “Suddenly the bottom of the glass burst, she recalled, “and the solution with the sediment poured on my jumpsuit. I went to the locker room to change my clothes. When I went past the dosimetry room, all the equipment went off the scales. The locker room attendant, however, refused to give me a fresh uniform, and so I had to work the rest of my shift without changing.”[35]

As the lab technicians started to become more anxious about the products they handled, the bosses disabused them of their fears. Kuz’ma Chernyshov, head of Shop Number Nine told his staff they had nothing to worry about it. To assure them, he would hold up a flask and ask, ‘Want a lick?’ He said that so often, the employees started to call him ‘Wanna-Lick.’ Another boss would push his staff to work faster, telling them, "Uncle Sam won't wait. Hurry up!"[36] But even if they had known of the dangers, the young workers probably would have continued as before. The bosses told their workers that the country was still at war: “People died at the front,” they said, “This is also the front."

Besides, the clean, quiet plants did not appear dangerous. Women who had worked in chemical plants learned to interpret danger as fire, smoke, noxious smells. There was little of that in the plutonium plant. Nor the usual hazards of a factory workers life—no spinning, finger-chopping lathes, heavy bone-crunching cranes, no crippling repetition before whirring

[34] Ibid: 54.
[35] Osoboe pokolenie: 67.
[36] Sokhina: 71-74.

machinery, no smog, heat, fire, swinging blades or deafening noises.

In August, 1949, the new metallurgical Factory no. 20 opened, a state-of-the-art facility—with lockers, showers, an alarm system, biological shielding, and special ventilation with gloves inserted for safe handling of radioactive substances. Instead of the old brick warehouse with a drowsy guard out front, employees entered and left the new plant through a brightly-lit tunnel of sanitized ceramic tile. They passed through a locker room, took off their street clothes and then walked in underwear past security officers who examined every bodily orifice for contraband. Employees then continued, passing radiation monitors, into a second locker room to change into white jumpsuits and rubber boots. In the course of 1949, scientists began to give lectures to staff on safe handling of radioactive solutions.[37] In theory, the plant should have improved both safety and production, but, like Factory no. 25, the new plant built in haste with conscripted labor, designed before experimental research had been completed, failed miserably. The first batch recovered only ten percent of the plutonium from the concentrate.[38] That was bad news for the waiting generals, but also for the workers. The missing plutonium remained in the factory, in glove boxes, conduits, beakers, and machinery. Nor did the new factory's safety features ensure protection. Because of a design flaws, staff often had to put their heads into glove boxes and directly inhale toxic substances. Eventually the employees dispensed with the boxes, and returned to mixing solutions as they had in the old workshops, filtering the plutonium and evaporating it in porcelain containers in the open. Radioactive waste was still hauled out about by hand. Workers still had to climb into vents to clean up dried plutonium dust. Carpenters started to renovate the plant soon after start-up, and, hopelessly contaminated, it

[37] Sokhina: IBID.
[38] Sokhina, 03: 81-83.

closed in 1954, as soon as its replacement was completed.[39]

In short, every step along the plutonium production line, Soviet workers, with their supervisors leading the way, were exposed externally and internally to radioactive and toxic contaminants. Many of the intricate devices and machinery built by rushed, tired, and harried workers on shoe-string budgets failed, or broke, or never really worked from the start. The automated trolleys transporting radioactive solutions to the chemical processing plant jammed and workers had to climb down into the trolley tracks to fix them. Plumbing with radioactive effluent clogged in narrow, twisting passages, which, regularly, had to be opened, crews using steel rods to push the deadly solutions along.[40] The rubber of the ventilated glove boxes disintegrated and contaminated air seeped from the chambers into the worker's area. Filters got clogged and had to be cleaned out by hand. Rubber stoppers fell apart and choked pipes, which plumbers had to cut open, clean out, and weld back together. Radioactive waste and radioactive equipment were carelessly dispensed or left in rooms where people worked. In some of these rooms, radioactivity reached 100 micro roentgen a second, meaning that without any extra accidents, staff received a dose of 10 roentgen a month, ten times the acceptable limit at the time.[41] In the first year and a half, 85% of all workers received more than the permissible dose (30 rems). Exposures got so bad that in May 1949, a plant doctor, A. P. Egorova, boldly sent a letter to Beria complaining about the "underestimation of the leaders of the Object of the fact that workers were getting irradiated."[42]

Fighting boldly these technological snags, the young, fleetingly-trained employees rushed

[39] The dosimetric service in 1954 found the level of contamination high enough to cause skin lesions. Sokhina, "Trudnosti puskogovo perioda," 144.

[40] Vladyslav B. Larin, "Mayak's Walking Wounded," *The Bulletin of the Atomic Scientists* September/October 1999: 22, 24.

[41] Sokhina, *Plutonii v devichikh rukakh*: 92-93.

[42] Novoselov and Tolstikov *Taina "Sorokovki:"* 148-149.

to make their deadlines. As they did, a beaker fell with a crash on the stone floor, a bucket was kicked over, a hand slipped into a solution, a valve was left on, or two barrels placed too close together exploded.[43] The staff tended to refer to these unclassified releases in shadow fashion, as spills/*utechki*, crumbles/*possypi*, dispersals/*vybrosy*, hotbeds/*otchagi*, or slaps/*khlopki*. Many of these events went unmonitored, unmeasured, unrecorded and necessarily unreported to stave off the security men, their black vehicles and pitiless investigations. These unnoted incidents were the usual fare of the dangerous reality of factory work, but as these episodes occurred in the world's second plutonium plant, they became major events in the history of radioactive contamination and, gradually, part of an invisible geography, which populated the new lakeside settlements around the plant with long-living radioactive isotopes that planted in soils, washed into streams and ponds, embedded in the roots and bodies of living organisms.

As the young workers met over lunch and dinner in their work clothes, hands unwashed, they laughed and talked. Most employees went home in the same garments, spreading, with a Hansel-and-Gretel-randomness, radioactive contaminants as they went. Workers at Plant no. 25 lived in the emerging plutonium city. Operators of Factory no. 20 resided in their own settlement fifteen kilometers from the main settlement. They lived in dorms and prefabricated houses, just a ten minute walk, in sight of the plant's smokestacks. The village had a shop, cafeteria, and a club house. The settlement was Spartan, but pretty. Like most Russians, they loved the rich, birch and pine forests that surrounded their town.

Unlike many industrial cities of the Urals, Plutopia had no belching factories that muddied the air, clouded the lakes and rained acid down on the forests. The 25-kilometer buffer zone around the city, created for security, dished up an accidental nature preserve. Larisa

[43] The first criticality incident occurred in 1947. Larin 2001: 26.

Sokhina remembered it fondly for its fruitfulness. “The village was surrounded by lakes and a forest, which was full of mushrooms and berries. The industrial Lake Kyzyltash had the most fish. The fisherman loved that lake, but they could not fish there for long. And Lake Irtiash was loved for its beauty. Irtiash in Bashkir means 'rocky place'. The shores were surrounded by high, rocky cliffs, and water in the lake was very clear.”[44]

There were some hardships. The dorms were crowded, often unsanitary and noisy. The food in the cafeteria was expensive and tasteless. There were few services—no barber, shoe repair, laundry, child care, or bus service to the main operator’s settlement.[45] Sokhina remembered the Gulag camp nearby; how in the mornings and evenings columns of prisoners, several hundred meters long, shuffled over the railroad crossing. The young women found it terrible to lay eyes on these men, ashen and menacing. In the evenings soldiers strolled on the paths from the nearby military base. The former frontline soldiers also terrified the women. It was chilling, to walk home alone, after a late night at work with the prisoners and soldiers lurking.[46]

“But the impression that we were depressed,” Sokhina recalled, “dispirited and frightened is wrong. We were mostly young people at the plant. We were energetic, joyful, and full of life.” The young employees played volleyball and basketball, arranged skiing competitions, hiking trips, and cookouts. They formed a wind orchestra, had parties and dances. Finally, after the miserable years of war there was enough sausage and vodka to make a party. Waltzes, tangos, fox-trots, the young people spun and twirled into a welcome oblivion. Cut off from their kin, the young employees remade family in the most, immediate, nuclear way. Couples married in

[44] Sokhina, *Plutonii v devichikh rukakh*, 37-38.

[45] "Postanovlenie biuro Cheliabinskogo Obkoma VKP o khode zhilishchnogo stroitel'stva po kombinate no. 817," 1 September 1948, OGACho 288/42/29.

[46] Ibid.: 36.

modest little weddings. As the young brides became pregnant, they kept working, their bellies swelling over the lab tables.

It was hard to set up house. Couples were thrilled to find a stool or bed to buy. One resourceful young father found some scrap metal near the reactor. He took the pipes home and welded them into a cot for his toddler. Only in 1957 did radiation monitors discover in the family apartment the child's bed, radiating powerfully. By that time, the boy had died, so too his mother. The father was very ill.[47]

In 1949, the tragedy of that family was still ahead, unseen, an accident yet in the making. In truth, the whole panorama—the operators village next to the plant processing green, highly-radioactive fuel, the make shift labs with no safety features, the workers walking home in radiated clothing spreading a path of contagion, commercial fishing in Lake Kyzyltash as it became the plutonium plant's great radioactive, toxic dump, the birch leaves in the village shimmering with radiation, young people gathering mushrooms and berries under them—all this was an accident, a calamity of ignorance, haste, and a sense of mission that spared no room for personal safety. Saving money, plant leaders had cut the budget for radiation monitoring, and so few grasped the dangerous surrounding them.[48] Sokhina and her colleagues had no idea in the heavy snow-muffled silence of the Urals' forest that they had already stepped downwind of their fate.

[47] Novoselov and Tolstikov *Taina "Sorokovki:"* 213.

[48] The monitoring budget was cut in 1948-1949 against the advice of the First Main Department's scientific committee. V. N. Novoselov and V. S. Tolstikov 1997: 148.