

The road to Chernobyl: Kurchatov, the F-1 and Chelyabinsk-40

by CM Meyer, technical journalist

This is the third in a series of articles being published in Energize tracing the history of nuclear energy throughout the world.

"The RBMK (RBMK essentially meaning high capacity channel-type reactor) evolved from Soviet uranium-graphite reactors whose purpose was the production of plutonium. The first of these plutonium production reactors began operation in 1948. Six years later, in 1954, a demonstration 5MWe RBMK-type reactor for electricity development began operation in Obninsk. Subsequently a series of RBMKs were developed using the combination of graphite moderation and water cooling in a channel design", Luis Lederman, Acting Head of the Safety Assessment Section in the IAEA Department of Nuclear Safety [12,1].

Before the reactor complex at Hanford was even started (in 1943 to produce plutonium for the American atom bombs), Groves had ensured that the effect of the slight radioactivity on salmon in the Columbia river was adequately studied [Rhodes, 1986a; 497]. Partly as a result of this study, water from the river that was pumped through the reactor to cool it was first held in a special tank for 3,3 hours (to allow most transient radioactivity to decay), carefully monitored for radioactive contamination, and then returned to the river. If any abnormal radioactive contamination was found, the water could be diverted to special holding basins [13;8]. Intensely radioactive wastes from reprocessing were not discharged into the Columbia river but stored in special underground containment tanks from the very beginning [Rhodes 1986a; 604].

By contrast, under Beria, the intense radioactive fission wastes were, by design, discharged directly into the Techa river [Rhodes, 1986b; 351]; which was also the source of drinking water for some 124 000 people living in villages on its banks. The Techa river's flow is far less than that of the Columbia river (estimated at between 95 to 130 cubic feet per second, compared with the average flow of the Columbia river at the Hanford site being 121 000 cubic feet per second). Thus, in contrast with the Columbia river at the Hanford site, substantial amounts of radioactive wastes could and did contaminate the banks of the

Techa river, [13;8], creating a human tragedy long before Chernobyl.

A much later book by the Medvedev brothers (Zhores and Roy) notes the following from Russian sources, "Some 124 000 people living in the flood lands of the Techa river in the Chelyabinsk and Kurgansk regions suffered from the radioactive pollution of the river and its banks. 28 000 people suffered from high doses of radiation (up to 170 ber - biological equivalents of roentgens). 935 cases of radiation sickness were recorded. About 8 000 inhabitants from 21 locations were resettled". But what is not commonly known is that the "8 000 inhabitants" were only resettled years later, in 1955 [Medvedev RA and ZA,2006;163].

An hour by the concrete lake

"At one time, the most contaminated side of the small bog-like lake Karachai, just a few hundred meters across, was so "hot"(radioactive) that a 30 minute exposure would be fatal for 50% of humans standing there for that period of time" [17;3].

In 1951, when it was found that radioactive waste dumped into the Techa river had flown into other rivers and eventually reached the Arctic, radioactive wastes were then dumped into an artificial lake specially dug for radioactive waste, lake Karachai. Only later, in 1953 and afterwards, was high-level waste housed in special tanks. In 1967, following several years of unusually low rainfall, the water level of lake Karachai receded and some 5 ha of land that had formerly been underwater became exposed. Unusually strong winds caused radioactive dust from this exposed part of the lake's sediments to be blown onto surrounding areas, causing considerable contamination of 1 800 km² [17; 7]. To remedy this, some 10 000 hollow concrete blocks were placed over the lake's sediments between 1978 and 1986, and filled with sand or stones.

The bizarre idea of the "concrete lake" at lake Karachai (and the fatal consequences of spending an hour there), inspired the Swedish group, Pain of Salvation, to produce an album in 1999 entitled "One hour by the concrete lake" [16;1].

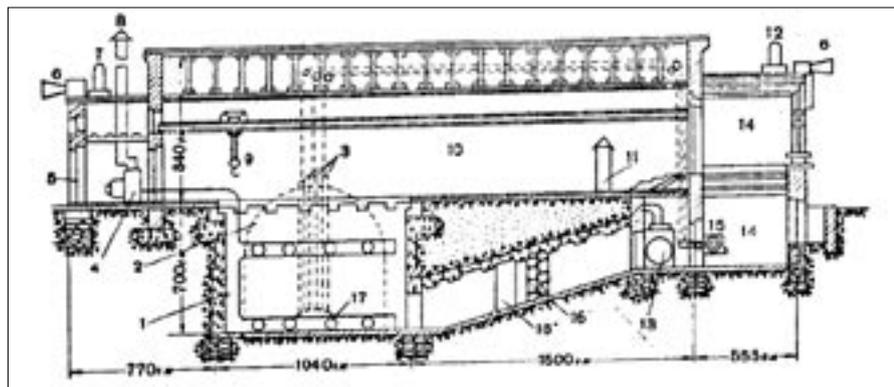
A real dictator

"In 1954, two options were studied regarding dual-purpose reactors that could combine generation of electrical power and production of weapons grade plutonium, i.e the RBMK-type reactor (high-capacity channel-type reactor) and the VVER-type reactor (water-cooled, water-moderated reactor [the Soviet equivalent of the West's PWR]) . The real development followed the path of plutonium production", Luis Lederman [14;1]

As Luis Lederman stated, RBMK reactors evolved from reactors whose priority had been the production of plutonium. As the above quote from the Rosenergoatom article notes, the "real development followed the path of plutonium production"[14;1]. This position was, in itself, then not much different from that in the United Kingdom (see "Part 8: "From MonteBello to Magnox Reactor and beyond"), where the urgent need to produce plutonium for military use was the real reason behind the first nuclear power plants in the United Kingdom: and not the generation of electricity. Or for that matter, that of the United States, where plutonium production had become an urgent priority, even in 1948 (see "Part 1 "The modus vivendi agreement between the USA and Great Britain" in the the October 2006 issue of Energize).

The tragedy was that, unlike in the USA and the United Kingdom, there was no strong regulator insisting on the importance of safety. In the USA, after Leslie Groves, Admiral Rickover had insisted that the lessons learned in building safe nuclear reactors for submarines be applied and communicated to all engaged in building reactors, and he had personally written most of the engineering codes for military and civilian nuclear power plants (see Parts 6 and 7. "The long shadow of Admiral Hyman Rickover").

In the UK, Christopher Hinton, in charge of designing reactors to produce plutonium and nuclear power, had insisted on gas-cooled reactors for reasons of safety (see Part 8. "From MonteBello to Magnox, and beyond"). As early as 1958 Hinton gave an eerily accurate description of just what



A schematic diagram of the F-1 reactor building. The F-1 reactor, the world's oldest operating reactor, is the igloo-like structure in the open pit.

hugely. Today, the sculpture of Kurchatov's head stands outside the institute named after him, and both he and his beard are immortalised in stone.

"The Beard" and the F-1 reactor

"Kurchatov quickly removed the two emergency rods from the reactor. As the seconds passed, the graph showed an almost linear growth of reactor power. For the first time the sound (of the neutron counters) turned into a roar. The indicator lamps (counting gamma rays) no longer blinked but burned with a reddish-yellow light", Physicist Igor Panasyuk describing when the first reactor in Russia went critical at 18h00 on December 25, 1946. [Rhodes, 1986b; 274]

Like the CP-1 (the very first American reactor) and GLEEP (the first reactor in Britain and in Europe), the F-1 (the first nuclear reactor to be built in the USSR) was cooled by air and moderated by graphite. And like the American reactor to which it bore a strong resemblance, the Hanford 305 (so-called because it was to be built in building 305 at Hanford), it was designed to test the purity of materials intended for a larger production reactor. Kurchatov soon learned that the uranium fuel and graphite moderator had to be incredibly pure for the reactor to work properly. Put another way, impurities in either uranium or graphite in samples sent into the core could be measured by the effect they had on the nuclear chain reaction.

In fact the F-1 bore more than a strong resemblance to the Hanford 305, it was practically a "carbon copy" of it, and there were strong suspicions that its details were obtained by industrial espionage. Although never confirmed by the Russians, it would have been no surprise, as Beria was obsessed with building working copies of tried and tested products [Rhodes 1986b; 268-269].

Kurchatov worked for Beria, the stress of which probably contributed to his death in 1960, aged only 57. As the only man initially allowed access to espionage data he often formulated requests and specific questions to Soviet intelligence on specific technical questions, and then had the responsibility to apply that knowledge. This included designing and building the first industrial reactor at Chelyabinsk-40 to produce plutonium.

He soon found out that espionage had not provided all the answers.

"The Beard" and the bomb

"No words could have replaced the force of his personal example. Kurchatov was

would happen in a major water-cooled reactor accident. As we shall see in the next article, he described almost exactly what was to happen in Chernobyl nearly thirty years later.

Instead of a benevolent dictator like Rickover, there were real dictators in the USSR (at first Stalin and Beria, then Khrushchev and then Brezhnev), laying down production goals for nuclear plants. At first the goals were for producing plutonium, then cheap electricity, and these goals usually outranked and directly opposed whatever attempts there were to apply safety directives [10;1].

At the time of the Chernobyl accident, when Gorbachev was in charge, electricity distribution officials interfered with the normal sequence of a safety test being conducted at Chernobyl 4 on 26 April 1986. This resulted in the first serious mistake made by the operator, who reduced power to 1% instead of 30%, all because he forgot to reset a controller. This sudden reduction in power resulted in a dangerous build-up of the radioactive gas xenon-135, which, as we shall see in the next article, was arguably the main cause of the accident. Because of its unforgiving design the reactor then became virtually impossible to operate safely. And, because the operator did not want to go against his superiors and call off the safety test, various safety measures were disabled to conduct the test, measures that soon caused things to go horribly and tragically wrong [18;10].

Indeed, there are some indications that there was a lot more involved in the safety test than is at first apparent. In his book "The legacy of Chernobyl", Zhores Medvedev makes a compelling case that overwhelming pressure to meet and exceed energy planning targets resulted in the Chernobyl plant being completed two months ahead of schedule. To "achieve" this, numerous short-cuts were taken, including the tacit acknowledgement that safety and other tests that should have

been done before the reactor started operation were to be done later. Limited space here does not allow for a proper discussion of Medvedev's argument.

Safety only really became a priority after the Chernobyl disaster. This was despite a major accident involving nuclear waste near the Chelyabinsk plant in 1957, which led to more than ten thousand people being evacuated from agricultural lands, and quite possibly ultimately lead to more deaths than from Chernobyl. The disasters at Kyshtym and Chernobyl are discussed in more detail in part 4, "Khrushchev and Kyshtym".

Laurenti Beria was eventually shot, ironically in December 1953, a few months after Stalin died. But by then he had laid his stamp on the Soviet nuclear programme: and reactor development. Chelyabinsk-40 was operating, and causing massive radioactive contamination to the environment. Although Beria never designed any reactors, he understood very little of the science involved, his continued interference and unrealistic deadlines were influence enough. He had demanded that Kurchatov produce copies of workable prototypes that were already functioning in the West (from plans that Soviet spies had already obtained or could obtain), instead of designing more advanced (or safer) versions from scratch.

Thus both Kurchatov's first nuclear reactor (the F-1), and first atom bomb (RDS-1) bore remarkable resemblances to what had already been developed in the West. Thanks to his remarkable intuition and hard work, Kurchatov built up the Soviet nuclear programme from nothing to rival that of the United States, living to see hydrogen bombs successfully tested. His nickname was "The Beard". This came from a long black beard he grew, originally from a decision not to shave until victory was achieved. Some time after, he was presented with a huge razor to shave off his beard, a gesture that he enjoyed

the first to step into the nuclear hell, into the central hall of the damaged reactor full of radioactive gases. He supervised the dismantling of the damaged channels and personally examined defects on the uranium blocks, piece by piece" [Medvedev, ZA and RA; 2006; 165-166]

A major crisis struck the Soviet nuclear programme on 20 January 1949. After operating for five months the reactor at Chelyabinsk-40 had to be shut down. The intense radiation had caused corrosion in the 1124 aluminium tubes containing the 39 000 uranium fuel blocks and to the aluminium cladding of some of the uranium blocks (each block was also covered by a thin layer of aluminium). The water flowing through the tubes to cool the reactor was now leaking into the graphite cladding surrounding the tubes, making it impossible to operate the reactor.

The team had already missed Stalin's original deadline of producing the first Soviet bomb by 1948, and had only recently solved a problem of argon and other gases produced by fission accumulating and making the uranium swell and distort, for which the reactor had to be shut down until the end of 1948 [Rhodes, 1986b, 331-332]. The next deadline, Beria had then promised to produce a bomb by Stalin's 70th birthday on 21 December 1949, was starting to look uncomfortably close, as the first Soviet atom bomb still had to be built and tested.

Under normal circumstances the fuel elements would have been allowed to drop down into water tanks and stand for at least 60 days for the worst radioactivity to decay. The fuel elements could then be moved to the reprocessing plant and the plutonium extracted. New aluminium pipes, this time with a strong anodal anti-corrosive covering, would be manufactured in an aircraft factory and then the reactor could be repacked with a fresh load of uranium fuel.

But these were not normal circumstances. If the team failed Stalin yet again and did not meet the deadline Beria had promised to Stalin, there was an excellent chance that Beria and the entire team would be summarily shot: like around 7-million other Russians had been. While the approximate rate of plutonium production by the reactor was known, nobody was, at that time, able to calculate precisely how much plutonium had been produced from the 150 tons of uranium in the reactor, and whether it would definitely be more than enough to produce at least one atom bomb. And there was no way that a new load of 150 tons of uranium

could be produced within the required period [Medvedev, ZA and RA,2006; 163-165].

Accordingly, a highly dangerous procedure was decided on. All 39 000 uranium blocks (by then, highly radioactive and also literally 'hot', at a temperature of over 100°C) would be removed and the reusable blocks sorted, all by hand. So, for five weeks the entire male workforce of the installation and thousands of prisoners (called zeks) worked in shifts at sorting out the blocks, while new aluminium pipes were made.

Kurchatov was head of the atomic programme, and had many privileges. But he alone had the experience to classify which blocks were re-usable. So he set the example and led the way into the reactor hall to supervise the operation. The account of the operation (by one Yefim Slavsky, then chief engineer and subsequently in charge of the entire Soviet nuclear industry for many years), does not state exactly how long Kurchatov worked in the central reactor hall.

But, even if he only worked a few shifts, the effects of his "courageous, even desperate action" soon became evident. He suffered "medium-intensity radiation sickness". Although this was not enough to "automatically lead to cancer and acute radiation sickness", this exposure, together with other exposures to radiation led to him, in the 1950s, rapidly becoming physically much weaker and often being ill.

In 1960 he died of a heart attack, aged only 57 [Medvedev, ZA and RA,2006;166]

At least two other senior officials involved in this operation reportedly also suffered damage to their health from radiation exposure and died comparatively young. These were Beria's deputy, General Avrami Zavenyagin, and Prof. Boris Nikitin, who worked at the installation.

Officially no one seems to know exactly how many of the thousands of prisoners who handled the radioactive blocks died or became seriously ill. But the Medvedev brothers do offer an indirect estimate: by the end of 1949 the number of prisoners in the forced labour unit attached to Chelyabinsk-40 had decreased by 3 000 [Medvedev, ZA and RA; 2006; 167].

At 07h00 on 29 August 1949 the first Soviet atom bomb was successfully tested at a range near Semipalatinsk. Kurchatov and Beria were among those watching from inside a bunker. On seeing the flash of light from the blast Kurchatov said just two words, "It worked". Wild with excitement (and probably relief), Beria ordered a telephone call put through to Stalin, who was then still asleep in Moscow.

The reported conversation went something like this:

Stalin (angry): "What do you want? Why are you calling?"

Beria: "Everything went right."

Stalin: "I know already."

And then Stalin abruptly hung up the phone [Rhodes, 1986b; 366-367].

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And what human health effects were before and after Chernobyl in the territory of the former USSR? The reviews on chronology of radiation incidents in the former USSR were done earlier [1,2,3], however, in the given paper we try to get more complete generalization of the available information, in which is the basis of the Registry of radiation accidents and incidents of the State Research Center - Institute of Biophysics (SRC-IBP). Tables 1 and 2 show that at least 349 radiation incidents with serious human overexposure have happened in the former USSR territory at the period since 1949 (each LRI case in "Mayak" PA is considered as the separate event in 1949-1956). Check out 'The Road to Chernobyl' by Conor Farrell and explore the story behind the world's worst nuclear accident. Available in paperback, on Kindle, and free for Kindle Unlimited members. <https://www.amazon.co.uk/Road-Chernobyl-Photographic-Tour/> See More. The Road to Chernobyl: A Photographic Tour. amazon.co.uk. The Road to Chernobyl: A Photographic Tour. The Road to Chernobyl: A Photographic Tour. The Road to Chernobyl: A Photographic Tour. The Road to Chernobyl. Not sure what to get the history buff in your life this Christmas? Pick up a copy of 'The Road to Chernobyl' and let them experience a photographic tour of the world's worst nuclear accident. Pick up 'The Road to Chernobyl' on Amazon: <http://amzn.to/2IOGI4Y>. The Road to Chernobyl. Monument to Kurchatov: Tickets & Tours. Travel Guides. Apps. Cruises. GreenLeaders. Road Trips. Skip to main content. Post. Alerts. Trips. Sign in. Inbox. See all. Log in to get trip updates and message other travelers. Chelyabinsk. Hotels. Things to do. Restaurants. Flights. Vacation Rentals. Kurchatov had moved from Kazan to Murmansk to work on mines for the Soviet Navy.[23]. In April 1942, Flyorov directed two classified letters to Stalin, warning him of the consequences of the development of atomic weapons: "the results will be so overriding [that] it won't be necessary to determine who is to blame for the fact that this work has been neglected in our country." [24]:xxx The second letter, by Flyorov and. Domestic production was still insufficient when the Soviet F-1 reactor, which began operation in December 1946, was fueled using uranium confiscated from the remains of the German atomic bomb project.