Ten Years of the Chornobyl Era

The environmental and health effects of nuclear power's greatest calamity will last for generations

by Yuri M. Shcherbak

> "It seemed as if the world was coming to an end . . . I could not believe my eyes; I saw the reactor ruined by the explosion. I was the first man in the world to see this. As a nuclear engineer I realized all the consequences of what had happened. It was a nuclear hell. I was gripped by fear."

These words were written to me in 1986 by the head of the shift operating the reactor that exploded at the Chornobyl nuclear power plant in northern Ukraine. The explosion and a resulting fire showered radioactive debris over much of eastern Europe. The author of the words above, along with several others, was later jailed for his role in the disaster, although he never admitted guilt.

Subsequent official investigations have shown, however, that responsibility for this extraordinary tragedy reaches far beyond just those on duty at the plant on the night of April 25 and early morning of April 26, 1986. The consequences, likewise, have spread far beyond the nuclear energy industry and raise fundamental questions for a technological civilization. Before the explosion, Chornobyl was a small city hardly known to the outside world. Since then, the name—often known by its Russian spelling, Chernobyl has entered the chronicle of the 20th century as the worst technogenic environmental disaster in history. It is an internationally known metaphor for catastrophe as potent as "Stalingrad" or "Bhopal." Indeed, it is now clear that the political repercussions from Chornobyl accelerated the collapse of the Soviet empire.

Because of the importance of this calamity for all of humanity, it is vital that the world understands both the reasons it happened and the consequences. The events that led up to the explosion are well known. Reactor number four, a 1,000-megawatt RBMK-1000 design, produced steam that drove generators to make electricity. On the night of the accident, operators were conducting a test to see how long the generators would run without power. For this purpose, they greatly reduced the power being produced in the reactor and blocked the flow of steam to the generators.

Unfortunately, the RBMK-1000 has a design flaw that makes its operation at low power unstable. In this mode of operation, any spurious increase in the production of steam can boost the rate of energy production in the reactor. If that extra energy generates still more steam, the result can be a runaway power surge. In addition, the operators had disabled safety systems that could have averted the reactor's destruction, because the systems might have interfered with the results of the test.

At 1:23 and 40 seconds on the morning of April 26, realizing belatedly that the situation had become hazardous, an operator pressed a button to activate the automatic protection system. The action was intended to shut the reactor down, but by this time it was too late. What actually happened can be likened to a driver who presses the brake pedal to slow down a car but finds instead that it accelerates tremendously.

Within three seconds, power production in the reactor's core surged to 100 times the normal maximum level, and there was a drastic increase in temperature. The result was two explosions that blew off the 2,000-metric-ton metal plate that sealed the top of the reactor, destroying the building housing it. The nuclear genie had been liberated.

Despite heroic attempts to quell the ensuing fire, hundreds of tons of graphite that had served as a moderator in the reactor burned for 10 days. Rising hot gases carried into the environment aerosolized fuel as well as fission products, isotopes that are created when uranium atoms split apart. The fuel consisted principally of uranium; mixed in with it was some plutonium created as a by-product of normal operation. Plutonium is the most toxic element known, and some of the fission products were far more radioactive than uranium or plutonium. Among the most dangerous were iodine 131, strontium 90 and cesium 137.

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A plume containing these radioisotopes moved with prevailing winds to the north and west, raining radioactive particles on areas thousands of miles away. Regions affected included not only Ukraine itself but also Belarus, Russia, Georgia, Poland, Sweden, Germany, Turkey and others. Even such distant lands as the U.S. and Japan received measurable amounts of radiation. In Poland, Germany, Austria and Hungary as well as Ukraine, crops and milk were so contaminated they had to be destroyed. In Finland, Sweden and Norway, carcasses of reindeer that had grazed on contaminated vegetation had to be dumped.

WIDESPREAD EFFECTS

The total amount of radioactivity released will never be known, but the official Soviet figure of 90 million curies represents a minimum. Other estimates suggest that the total might have been several times higher. It is fair to say that in terms of the amount of radioactive fallout—though not, of course, the heat and blast effects—the accident was comparable to a medium-size nuclear strike. In the immediate aftermath of the explosion and fire, 187 people fell ill from acute radiation sickness; 31 of these died. Most of these early casualties were firefighters who combated the blaze.

The destroyed reactor liberated hundreds of times more radiation than was produced by the atomic bombings of Hiroshima and Nagasaki. The intensity of gamma radiation on the site of the power plant reached more than 100 roentgens an hour. This level produces in an hour doses hundreds of times the maximum dose the International Commission on Radiological Protection recommends for members of the public a *year.* On the roof of the destroyed reactor building, radiation levels reached a frightening 100,000 roentgens an hour.

The human dimensions of the tragedy are vast and heartbreaking. At the time of the accident, I was working as a medical researcher at the Institute of Epidemiology and Infectious Diseases in Kiev, some 60 miles from the Chornobyl plant. Sometime on April 26 a friend told me that people had been arriving at hospitals for treatment of burns sustained in an accident at the plant, but we had no idea of its seriousness. There was little official news during the next few days, and what there was suggested the danger was not great. The authorities jammed most foreign broadcasts, although we could listen as Swedish radio reported the detection of high levels of radioactivity in that country and elsewhere. I and some other physicians decided to drive toward the accident site to investigate and help as we could.

We set off cheerfully enough, but as we got closer we started to see signs of mass panic. People with connections to officialdom had used their influence to send children away by air and rail. Others without special connections were waiting in long lines for tickets or occasionally storming trains to try to escape. Families had become split up. The only comparable social upheaval I had seen was during a cholera epidemic. Already many workers from the plant had been hospitalized.

The distribution of the fallout was extremely patchy. One corner of a field might be highly dangerous, while just a few yards away levels seemed low. Nevertheless, huge areas were affected. Although iodine 131 has a half-life of only eight days, it caused large radiation exposures during the weeks immediately following the accident. Strontium 90 and cesium 137, on the other hand, are more persistent. Scientists believe it is the cesium that will account for the largest radiation doses in the long run.

All told, well over 260,000 square kilometers of territory in Ukraine, Russia and Belarus still have more than one curie per square kilometer of contamination with cesium 137. At this level, annual health checks for radiation effects are advised for residents. In my own country of Ukraine, the total area with this level of contamination exceeds 35,000 square kilometers—more than 5 percent of the nation's total area. Most of this, 26,000 square kilometers, is arable land. In the worst affected areas there are restrictions on the use of crops, but less contaminated districts are still under cultivation.

The heavily contaminated parts of Ukraine constitute 13 administrative regions (oblasts). In these oblasts are 1,300 towns and villages with a total population of 2.6 million, including 700,000 children. Within about 10 days of the accident, 135,000 people living in the worst-affected areas had left their homes; by now the total has reached 167,000. Yet it is clear that the authorities' attempts to keep the scale of the disaster quiet actually made things worse than they need have been. If more inhabitants in the region had been evacuated promptly during those crucial first few days, radiation doses for many people might have been lower.

The region within 30 kilometers of the Chornobyl plant is now largely uninhabited; 60 settlements outside this zone have also been moved. Formerly busy communities are ghost towns. The government has responded to this unprecedented disruption by enacting laws giving special legal status to contaminated areas and granting protections to those who suffered the most. Yet the repercussions will last for generations.

MULTIPLE ILLNESSES

The medical consequences are, of course, the most serious. Some 30,000 people have fallen ill among the 400,000 workers who toiled as "liquidators," burying the most dangerous wastes and constructing a special building around the ruined reactor that is universally referred to as "the sarcophagus." Of these sick people, about 5,000 are now too ill to work.

It is hard to know, even approximately, how many people have already died as a result of the accident. Populations have been greatly disrupted, and children have been sent away from some areas. By comparing mortality rates before and after the accident, the environmental organization Greenpeace Ukraine has estimated a total of 32,000 deaths. There are other estimates that are higher, and some that are lower, but I believe a figure in this range is defensible. Some, perhaps many, of these deaths may be the result of the immense psychological

stress experienced by those living in the contaminated region.

One medical survey of a large group of liquidators, carried out by researchers in Kiev led by Sergei Komissarenko, has found that most of the sample were suffering from a constellation of symptoms that together seem to define a new medical syndrome. The symptoms include fatigue, apathy and a decreased number of "natural killer" cells in the blood.

Natural killer cells, a type of white blood cell, can kill the cells of tumors and virus-infected cells. A reduction in their number, therefore, suppresses the immune system. Some have dubbed this syndrome "Chornobyl AIDS." Besides having increased rates of leukemia and malignant tumors, people with this syndrome are susceptible to more severe forms of cardiac conditions as well as common infections such as bronchitis, tonsillitis and pneumonia.

As a consequence of inhaling aerosols containing iodine 131 immediately after the accident, 13,000 children in the region experienced radiation doses to the thyroid of more than 200 roentgen equivalents. (This means they received at least twice the maximum recommended dose for nuclear industry workers for an entire year.) Up to 4,000 of these children had doses as high as 2,000 roentgen equivalents. Because iodine collects in the thyroid gland, these children have developed chronic inflammation of the thyroid. Although the inflammation itself produces no symptoms, it has started to give rise to a wave of cases of thyroid cancer.

The numbers speak for themselves. Data gathered by the Kiev researcher Mykola D. Tronko and his colleagues indicate that between 1981 and 1985—before the accident—the number of thyroid cancer cases in Ukraine was about five a year. Within five years of the disaster the number had grown to 22 cases a year, and from 1992 to 1995 it reached an average of 43 cases a year. From 1986 to the end of 1995, 589 cases of thyroid cancer were recorded in children and adolescents. (In Belarus the number is even higher.) Ukraine's overall rate of thyroid cancer among children has increased about 10-fold from preaccident levels and is now more than four cases per million. Cancer of the thyroid metastasizes readily, although if caught early enough it can be treated by removing the thyroid gland. Patients must then receive lifelong treatment with supplemental thyroid hormones.

Other research by Ukrainian and Israeli scientists has found that one in every three liquidators—primarily men in their thirties—has been plagued by sexual or reproductive disorders. The problems include impotence and sperm abnormalities. Reductions in the fertilizing capacity of the sperm have also been noted. The number of pregnancies with complications has been growing among women living in the affected areas, and many youngsters fall prey to a debilitating fear of radiation.

The optimists who predicted no long-term medical consequences from the explosion have thus been proved egregiously wrong. These authorities were principally medical officials of the former Soviet Union who were following a script written by the political bureau of the Communist Party's Central Committee. They also include some Western nuclear energy specialists and military experts.

It is also true that the forecasts of "catastrophists"—some of whom predicted well over 100,000 cancer cases—have not come to pass. Still, previous experience with the long-term effects of radiation—much of it derived from studies at Hiroshima and Nagasaki—suggests that the toll will continue to rise. Cancers caused by radiation can take many years before they become detectable, so the prospects for the long-term health of children in the high-radiation regions are, sadly, poor.

The hushing up of the danger from radiation in Soviet propaganda has produced quite the opposite effects from those intended. People live under constant stress, fearful about their health and, especially, that of their children. This mental trauma has given rise to a psychological syndrome comparable to that suffered by veterans of wars in Vietnam and Afghanistan. Among children evacuated from the reactor zone, there has been a 10- to 15-fold increase in the incidence of neuropsychiatric disorders.

The catastrophe and the resulting resettlement of large populations have also caused irreparable harm to the rich ethnic diversity of the contaminated areas, particularly to the so-called *drevlyany,* woodland people, and *polishchuks,* inhabitants of the Polissya region. Unique architectural features and other artifacts of their spiritual and material culture have been effectively lost as abandoned towns and villages have fallen into disrepair. Much of the beautiful landscape is now unsafe for humans.

The Ukrainian government, which is in a severe economic crisis, is today obliged to spend more than 5 percent of its budget dealing with the aftermath of Chornobyl. The money provides benefits such as free housing to about three million people who have been officially recognized as having suffered from the catastrophe, including 356,000 liquidators and 870,000 children. Ukraine has introduced a special income tax corresponding to 12 percent of earnings to raise the necessary revenue, but it is unclear how long the government can maintain benefits at current levels.

Today the Chornobyl zone is one of the most dangerously radioactive places in the world. In the debris of the ruined reactor are tens of thousands of metric tons of nuclear fuel with a total radioactivity level of some 20 million curies. The radiation level in the reactor itself, at several thousand roentgens per hour, is lethal for any form of life. But the danger is spread far and wide. In the 30-kilometer zone surrounding the reactor are about 800 hastily created burial sites where highly radioactive waste, including trees that absorbed radioisotopes from the atmosphere, has been simply dumped into clay-lined pits.

These dumps may account for the substantial contamination of the sediments of the Dnieper River and its tributary the Pripyat, which supply water for 30 million people. Sediments of the Pripyat adjacent to Chornobyl contain an estimated 10,000 curies of strontium 90, 12,000 curies of cesium 137 and 2,000 curies of plutonium. In order to prevent soluble compounds from further contaminating water sources, the wastes must be removed to properly designed

and equipped storage facilities—facilities that do not yet exist.

COST OF CLEANUP

The two reactors that are still in operation at the Chornobyl plant also pose a major problem (a fire put a third out of action in 1992). These generate up to 5 percent of Ukraine's power; the nuclear energy sector altogether produces 40 percent of the country's electricity. Even so, Ukraine and the Group of Seven industrial nations last December signed a formal agreement on a cooperative plan to shut down the whole Chornobyl plant by the year 2000. The agreement establishes that the European Union and the U.S. will help Ukraine devise plans to mitigate the effects of the shutdown on local populations. It also sets up mechanisms to allow donor countries to expedite safety improvements at one of the reactors still in use. In addition, the agreement provides for international cooperation on decommissioning the plant, as well as on the biggest problem of all: an ecologically sound, long-term replacement for the sarcophagus that was built around the ruin of reactor number four.

The 10-story sarcophagus, which is built largely of concrete and large slabs of metal and has walls over six meters thick, was designed for a lifetime of 30 years. But it was constructed in a great hurry under conditions of high radiation. As a result, the quality of the work was poor, and today the structure is in need of immediate repair. Metal used in the edifice has rusted, and more than 1,000 square meters of concrete have become seriously cracked. Rain and snow can get inside. If the sarcophagus were to collapse—which could happen if there were an earthquake—the rubble would very likely release large amounts of radioactive dust.

In 1993 an international competition was held to find the best long-term solution. Six prospective projects were chosen for further evaluation (out of 94 proposals), and the next year a winner was selected—Alliance, a consortium led by Campenon Bernard of France. The consortium's proposal, which entails the construction of a "supersarcophagus" around the existing one, unites firms from France, Germany, Britain, Russia and Ukraine. The group has already conducted feasibility studies. If the project goes forward, design work will cost $20 million to $30 million, and construction—which would take five years—upwards of $300 million. Final disposal of the waste from the accident will take 30 years. One possibility being explored is that the waste might be encased in a special glass.

Chornobyl was not simply another disaster of the sort that humankind has experienced throughout history, like a fire or an earthquake or a flood. It is a global environmental event of a new kind. It is characterized by the presence of thousands of environmental refugees; long-term contamination of land, water and air; and possibly irreparable damage to ecosystems. Chornobyl demonstrates the ever growing threat of technology run amok.

The designers of the plant, which did not conform to international safety requirements, are surely culpable at least as much as the operators. The RBMK-1000 is an adaptation of a military reactor originally designed to produce material for nuclear weapons. There was no reinforced containment structure around the reactor to limit the effects of an accident. That RBMK reactors are still in operation in Ukraine, Lithuania and Russia should be cause for alarm.

The disaster illustrates the great responsibility that falls on the shoulders of scientific and other experts who give advice to politicians on technical matters. Moreover, I would argue that the former Soviet Union's communist leadership must share the blame. Despite then President Mikhail S. Gorbachev's professed support for glasnost, or openness, the regime hypocritically closed ranks in the aftermath of the tragedy in a futile and ultimately harmful attempt to gloss over the enormity of what had occurred.

The event offers a vivid demonstration of the failures of the monopolistic Soviet political and scientific system. The emphasis under that regime was on secrecy and on simplifying safety features in order to make construction as cheap as possible. International experience with reactor safety was simply disregarded. The calamity underscores, further, the danger that nuclear power plants could pose in regions where wars are being fought. Of course, all such plants are potentially vulnerable to terrorist attack.

Chornobyl has taught the nations of the world a dreadful lesson about the necessity for preparedness if we are to rely on nuclear technology. Humankind lost a sort of innocence on April 26, 1986. We have embarked on a new, post-Chornobyl era, and we have yet to comprehend all the consequences.

FURTHER READING

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