NUCLEAR ENERGY IN THE RUSSIAN FEDERATION

With a total nuclear energy capacity of about 21,000 megawatts, Russia is the largest producer of nuclear-generated electricity among the three former Soviet republics with operating plants.

In 1996, 29 nuclear units generated 13.1 percent of the Russian Federation's power, up from 11.8 percent in 1995. Certain regions of the republic are heavily dependent on nuclear power. The Leningrad, Kola and Smolensk nuclear plants supply half of northwest Russia's electricity requirements. In Central Russia, almost one-third of the area's power is nuclear generated.

In addition to nuclear power, Russia generates 69 percent of its electricity at thermal power stations (coal, gas and oil) and 18 percent at hydroelectric stations.

Total overall electricity production in Russia has been falling for several years. In 1993, output was down by 7 percent; thermal power accounted for most of the decline, while nuclear generation slid less than 1 percent. In 1994, output was down by 13 percent, but nuclear production slid by 18 percent. In 1995, total electricity output was down by 2 percent, with nuclear production up by about 1 percent. Total power generation for 1996 fell by 1.5 percent, while nuclear output jumped by 9.5 percent.

Nuclear Program and Plans

Since the Soviet Union collapsed, the Russian Federation has faced the challenge of improving safety at its nuclear power plants, especially those of the first generation, maintaining its plants in accordance with international safety requirements, and continuing its plans for building newer models.

Operating Performance. In 1992, Russian VVER reactors had an average capacity factor of 69.4 percent, while the country's RBMK reactors had an average capacity factor of 65.7 percent. The average capacity factor for all Russian nuclear plants rose to 67.3 percent in 1993, but fell to 52.6 percent in 1994. It rose again in 1995—to 53.2 percent—and then climbed to 58.3 percent in 1996.

The number of International Nuclear Safety Event reports for 1996 fell to 87 from 100 in 1995. Of the 1996 events, only two were classified as Level 1—an anomaly. The rest had no safety significance.

Initial Plan for New Capacity. In a statement issued Dec. 28, 1992, Russian Prime Minister Viktor Chernomyrdin announced the republic's 20-year nuclear plant construction plan. The objective was to add approximately 16,500 megawatts of nuclear capacity by 2015, of which 2,000 megawatts were for heating only.

Following the 1986 Chernobyl accident, all nuclear plant construction had been suspended. The new Russian plan revived construction on five units, including a VVER-1000 unit at Balakovo and one at Kalinin, and an RBMK unit at Kursk. Balakovo 4 came on line in April 1993.

Cancellation of Plan. In November 1993, Russia's Supreme Soviet—the parliamentary upper house—canceled the 20-year plan announced in late 1992. According to an official of Gosatomnadzor, the Russian regulatory agency, construction of Kursk Unit 5 and Kalinin Unit 3 was stalled because of lack of funding.

New Nuclear Strategy. In May 1994, the Ministry of Atomic Energy (Minatom) issued a draft strategy for nuclear energy through the year 2010 that sought to carry out the original 1992 plan. The strategy identified several new-generation reactors being designed in Russia:

- the NP-1000 (a 1,000-megawatt VVER with enhanced safety features),
- the NP-1100 (a 1,100-megawatt VVER with enhanced safety features),
- the NP-500 (a 640-megawatt VVER with enhanced safety features),
- the VPBER-600 (a 640-megawatt boiling water reactor with passive safety features),
- the BN-800 (an 800-megawatt fast breeder reactor), and
- the MKER-800 (an 800-megawatt channel-type reactor with enhanced safety features).

According to a Rosenergoatom official, Sosnovyy Bor was chosen as the site for the first NP-500, Novovoronezh for the first NP-1000 or NP-1100, and the Primorskaya and Kostroma sites for the first VPBERs. Design work on the NP-500 was completed in 1993, while design work on the NP-1000 and VPBER-600 was expected to be completed by the end of 1994, and on the NP-1100 in 1997.

Revised Construction Program. In December 1995, a Minatom spokesman discussed the status of Russian plants under construction and planned. He said that completion of the new 640-megawatt VVER reactor—also known as the V-407—could be delayed by several years because of financial difficulties.

The VVER-640, planned for construction at a site adjacent to the Leningrad plant at Sosnovyy Bor, was originally scheduled to come on line in 1999, but Minatom now expects start-up in 2002. If this pilot project is successful, three VVER-640s with an installed capacity of 1,935 megawatts are slated for construction 9 kilometers from the existing Kola plant. The new plant, Kola NPP-2, will provide replacement power when Kola units 1 and 2, two VVER-440 Model V230s, are shut down.

In mid-1996, Gosatomnadzor (GAN) authorized construction of VVER-640 plants at Sosnovyy Bor and near the Kola plant.

The Leningrad plant is reportedly planning its own reactor project to replace units 1 and 2, but has yet to decide on a reactor type. Its options are: the MKER-800, an advanced channel-type reactor; the VVER-1000; or the VVER-640.

VVER-1000 Completion Plans. Of the VVER-1000 units earmarked for completion under the 1992 Russian plan, Kalinin 3—originally scheduled to come on line in 1995—is expected to be operational by 2000, according to a Minatom official. Other units expected to come on line by 2000 are Balakovo 5, a VVER-1000, and Rostov 1, a VVER 1000 that is reportedly 97 percent complete. A second unit at Rostov is said to be 95 percent complete, but there is local opposition to both projects. Russia's new energy law requires the approval of local authorities for plant construction.

Two new reactors, VVER-1000s with enhanced safety features, will be built at Novovoronezh. An application for authorization of the project from GAN is being prepared, and work is expected to begin by 2000.

RBMK Completion Plans. Another planned addition is Kursk 5, reportedly a third-generation RBMK unit, not the advanced MKER-800. In November 1996, plant management reportedly said that 2.3 billion rubles were needed for construction, but the money was not available. But a Minatom official said in February 1997 that the government had provided construction funding and unit could be completed in 1998.

Fast Breeder Projects. Minatom also plans to build plants with an improved fast breeder reactor. GAN is reviewing applications for construction permits at Beloyarsk, site of the BN-600, an earlier model of the fast breeder, and at the South Urals site.

Beloyarsk plant management reported in June 1997 that GAN, the Russian nuclear inspectorate, had approved the construction of a BN-800 at the site, provided some required changes are made in the plant's design. Construction of the unit, which is estimated to cost $1 billion, is to be financed by Rosenergoatom, the Sverdlovsk regional administration and two Russian energy companies. Construction of the unit, which is now reportedly 8 percent complete, is expected to be resumed in 1998 and be finished by about 2005.

Two BN-800s—rather than the three originally planned—are now scheduled for construction at the South Urals site, but not until sometime after the year 2000. In late 1993, the Chelyabinsk local council approved a project to build three BN-800 units at the South Urals site. The project, shelved in 1987 because of local opposition, was revived because of electricity shortages, but construction was not resumed because of a lack of funding. In May 1996, however, a senior Russian government official said that the government planned to provide some funding for construction of two BN-800s, adding that at least 66 billion rubles would be needed for work in 1996.

Floating Nuclear Plants. To meet electricity demand in remote northern and eastern areas of Russia, the government plans to build up to 15 small floating nuclear power plants. Each plant, based on the KLT-40 design used to power Russia's nuclear icebreakers, would consist of two 35-megawatt reactors. The reactors would be installed on medium-sized vessels and towed to the areas of operation. The vessels would return to port once every 13 years for maintenance, removal of spent fuel and loading of fresh fuel.

There are reportedly about 50 sites along Russia's Arctic coastline that would be suitable for such floating plants. Plans call for the first plant to operate near the Arctic seaport of Pevek on the Chukotka peninsula in northeastern Russia. Such a plant is also an option to replace power from the Bilibino nuclear plant, whose units will reach the end of their service life between 2004 and 2006.

Nuclear Plant Referendum. In December 1996, the residents of Russia's Kostroma region—190 miles northeast of Moscow—voted against the construction of a nuclear power plant near the town of Kostroma. Nearly 90 percent of voters opposed construction. The Soviet government originally planned to build an RBMK plant at the site, but after the Chernobyl accident proposed the construction of VVER-1000 units instead. Only a management office and living quarters were built, according to Minatom. In 1994, the regional parliament approved a plan to build two VPBER-600 units—a 600-megawatt boiling water reactor with passive safety features—at the site, and reportedly urged the Russian government to include the plant in its nuclear construction program.

Decommissioning Plans. Rosenergoatom has reportedly announced that all first-generation nuclear units will be decommissioned by 2005. These units include the four RBMKs at the Leningrad plant, and four VVER-440 Model V230s—two at the Kola plant and two at the Novovoronezh plant. These units are operating on the basis of annual permits, however, and if replacement plants are delayed in coming on line, the first-generation units could continue operating beyond their scheduled closure dates.

Under an April 1997 government decree, federal executive organs responsible for the use of nuclear energy are to include the cost of nuclear power plant decommissioning in their budgets.

Planned Additions to Russia's Nuclear Capacity

Reactor Type	Unit Name	Operating Target Dates
VVER-1000	Kalinin 3	2000
RBMK-1000	Kursk 5	2000
Pilot VVER-640	Sosnovyy Bor	2002
VVER-1000 (enhanced safety)	Novovoronezh 6 Novovoronezh 7	2002 2005
VVER-640 (enhanced safety)	Kola NPP2, Unit 1 Kola NPP-2, Unit 2 Kola NPP-2, Unit 3	2003 2004 2005
VVER-1000	Balakovo 5 Balakovo 6	2000 2005
District Heating Plant (500 MW)	Voronezh 1 Voronezh 2	1997 1999
BN-800 (fast breeder reactor)	South Urals 1 South Urals 2 Beloyarsk 4	2003 2005 2005
District Heating Plant (500 MW)	Khabarovsk 1 Khabarovsk 2	2004 2006

Operating Organizations

Nuclear Electricity Generation. Rosenergoatom is responsible for operating all of Russia's nuclear power plants but the Leningrad nuclear plant at Sosnovyy Bor. The Leningrad plant has the status of a separate operating utility. Both are responsible for plant maintenance and repair, technical support, operations planning, and emergency planning.

In addition, Rosenergoatom is responsible for building nuclear power plants, developing and implementing nuclear plant commissioning programs, modernizing nuclear plants, supporting the nuclear plants financially and logistically, and training operators and maintenance personnel, using VVER-440 and VVER-1000 simulators at Novovoronezh and an RBMK simulator at Smolensk. The organization uses revenue from some of the nuclear energy it sells to ensure the plants' safe operation, and to support the design and construction of new plants, the upgrading of older plants and the decommissioning of plants that have reached the end of their operating life.

Rosenergoatom maintains a centralized system in Moscow that collects, processes and disseminates information on operational events. It also reports any event to the International Atomic Energy Agency for a rating on the International Nuclear Event Scale.

The Russian nuclear plants use the information from Rosenergoatom in making equipment modifications as well as in personnel training.

Organizationally, Rosenergoatom and the Leningrad nuclear plant are part of the Russian Ministry of Atomic Energy, and their activities are overseen by First Deputy Minister L.D. Ryabev. On Jan. 1, 1997, Vitaliy Ignatenko was appointed to the newly created position of Rosenergoatom general director; Erik Pozdyshev remained as president.

Non-Nuclear Electricity Generation. Russia's Ministry of Fuel and Power is responsible for formulating electricity policy and supervising electricity generation at Russia's thermal and hydro power plants.

Electricity Distribution and Sale. The Russian Joint Stock Company for the United Power System (RAO-YeES) distributes and sells electricity in Russia. It owns the biggest thermal and hydro plants in the country—those over 1,000 megawatts, which represent about half of Russia's non-nuclear electricity generating capacity—as well as all the high-voltage transmission lines of more than 300 kV in Russia.

The rest of Russia's thermal and hydro capacity—about 60 percent of the country's total installed capacity—is owned by local power companies. Some of these companies, in turn, are owned by RAO-YeES. The Russian government owns 51 percent of RAO-YeES, with the remainder of the company held privately.

RAO-YeES controls the wholesale electricity market, buying all the output of the 21 individual utility companies and most of Rosenergoatom's output. Some of Russia's nuclear power plants have attempted—unsuccessfully—to bypass RAO-EES, seeking to negotiate power supply agreements directly with regional and local power systems not wholly owned by RAO-YeES.

Changes to Electricity Market. In July 1996, Russian President Boris Yeltsin issued an edict on guaranteeing the safe operation of the country's nuclear power plants. The decree called on the government to develop and approve by August 1 the basic principles of a wholesale electricity market for the country. Yeltsin also charged the government with defining a mechanism whereby power-intensive consumers could pay nuclear plants directly for the electricity received. He obligated the government to take steps to pay the wages owed to nuclear plant staff, and urged RAO-YeES to pay off its debts to nuclear plants. According to the edict, RAO-YeES payments to Rosenergoatom and the nuclear plants for electricity sales should be proportionate to nuclear energy's share of the total electricity market. The edict instructed that the payments be used to improve nuclear plant safety.

In accordance with the edict, RAO-YeES should have transferred 82.1 billion rubles to the nuclear plants—to cover April-May wage payments—by Sept. 1. But the company had transferred only 18.6 billion rubles, said Rosenergoatom. RAO-YeES itself reportedly receives only 15 rubles for every 100 rubles of electricity it sells; the rest takes the form of barter.

Under a decree issued by President Yeltsin in April 1997, electricity generators can sell their power directly to distribution companies in a regulated national wholesale market. The reform, which involves the natural gas industry and rail sector as well as the electricity industry, is expected to be completed by 2000. According to a law passed by the Duma, Russia's lower house of parliament, in June, the government will retain its 51 percent share of RAO-YeES and keep the national power supply system intact. Foreign governments, international organizations, foreign legal entities and foreign individuals can own up to 25 percent of all forms of RAO-YeES shares. Russia's upper house of parliament, the Federation Council, approved the legislation in early July. But in late July, President Yeltsin vetoed the bill.

Electricity Prices. In the fall of 1995, the government froze all prices for electricity, as well as for natural gas and railroad shipping, between Oct. 1 and Jan. 1, 1996, in an effort to curb inflation. The Economics Ministry reportedly proposed a 16 percent increase in electricity prices, to take effect on or after Feb. 15, 1996. However, in August 1996 the Russian media reported that the government had frozen electricity prices until October, when it planned to introduce higher tariffs. The cost of electricity for domestic consumers, for example, was expected to rise from 68 rubles per kilowatt-hour to 200 rubles/kWh.

In April 1997, RAO-YeES announced plans to reduce electricity tariffs for industrial customers by 13 percent, with a further cut of 25 percent planned for 1998. However, under a government plan to reform the national electricity system, prices for residential customers will rise at least 2½ times, while a graduated rate system will be introduced for industrial customers. Once reform of the system is completed, the average rate for industrial customers will be at least 40 percent lower than it is now.

East-West Power Link. RAO-YeES—together with the Belarusian Energy Ministry , Poland's PPGC power grid operation and Germany's VEAG and PreussenElektra—proposed an 1,800-kilometer, 500-kilovolt power transmission line that would link the grids of Russia and Western Europe.

Nuclear Energy Oversight

Gosatomnadzor (GAN)—the State Committee for Nuclear and Radiation Safety—is responsible for regulatory oversight of Russia's civilian nuclear power plants. In July 1995, President Yeltsin issued a directive stating that GAN would be responsible for oversight of civilian facilities only; the Ministry of Defense is to have responsibility for all military nuclear facilities.

GAN, which is headed by Yuriy Vishnevskiy, reports directly to President Yeltsin. GAN licenses all civilian facilities that use radioactive materials, develops rules and standards governing the safe use of these materials, and inspects all facilities that use these materials, including nuclear power plants. GAN is also charged with approving the design and construction of all nuclear plants.

The agency sets the skill requirements of all personnel responsible for the safe operation of nuclear plants, and ensures that those requirements are met. GAN is responsible for analyzing all nuclear plant incidents and recommending any necessary corrective measures. It also provides information on events that must be reported outside the plant. GAN has the authority to shut down or withdraw the operating license of any facility that violates its nuclear safety requirements.

In addition to its headquarters in Moscow, GAN has seven regional branches: St. Petersburg, Balakovo, Yekaterinburg, Khabarovsk, Moscow, Novovoronezh and Novosibirsk. There is at least one resident inspector at almost every Russian nuclear plant.

At present, Russia's nuclear plants operate on the basis of temporary permits, but the permits do include requirements on improvement programs and independent assessments. According to GAN officials, the agency plans to develop a full-scope licensing regime based on that used in the United States.

In November 1996, a GAN spokesman reportedly told the Interfax news agency that GAN's work was paralyzed because of lack of funding. He said the Finance Ministry had not given the agency funding allocated to it in the 1996 budget.

Impact of Financial Difficulties

Since the beginning of 1993, Russia's nuclear plants have failed to receive full payment for the electricity they supply to RAO-EES. RAO-EES is delaying—or failing to make—payments to Rosenergoatom because it is not being paid by Russia's electricity consumers. As a result, many of Russia's nuclear plants have been unable to pay their staff or purchase needed fuel and spare parts.

During the winter of 1994, the directors of a number of Russian nuclear plants—among them Leningrad, Smolensk, Kursk, Novovoronezh and Kola—said they might have to shut down if they did not get money for fuel and spare parts. In the spring, workers from nine nuclear plants demonstrated in Moscow to demand that they be paid. By law, nuclear plant workers are forbidden to strike.

The government responded by approving 50 billion rubles in emergency credit. As of mid-June, however, the money had not been transferred to the Ministry of Atomic Energy, and Rosenergoatom reported that maintenance had been suspended at many plants.

Rising Tide of Debt. By the end of 1994, Rosenergoatom was reportedly owed 1.6 trillion rubles by RAO-EES, and Rosenergoatom itself owed 1.45 trillion rubles to other organizations. Debts to Rosenergoatom continued to rise in 1995, with nuclear electricity consumers owing 2.1 trillion rubles by October of that year

In September 1995, the Kola nuclear power plant cut off power to the nuclear submarine base of the Russian Northern Fleet because the base had not paid its electricity bills. As a result of this and other similar incidents at Russian military bases, Prime Minister Chernomyrdin signed an order in late September prohibiting regional power systems from cutting off electricity to military installations. In November, the Russian government adopted a resolution—effective until May 15, 1996—prohibiting the disconnection of electricity, gas, heat or other fuel supplies to the country's most important facilities, including those belonging to the Ministry of Defense. Later that month, Russia's parliament submitted a law to President Yeltsin that would make it a crime to cut off electricity supplies to military facilities.

In an attempt to improve the plants' financial situation, the Russian government decreed that effective Jan. 1, 1996, all enterprises must pay for electricity consumed, and nuclear power plants will be taxed on the basis of revenue received, not electricity produced.
However, Rosenergoatom received only 2 percent of the money owed it in cash in 1996, with the rest in reciprocal payments, barter and promissory notes. Because of funding shortages, scheduled maintenance work was carried out at only 19 of 25 units in 1996.

In January 1997, Aleksey Bolshakov, Russia's first deputy prime minister, asked the ministries of Finance and Fuel and Power Engineering and RAO-YeES to find 2 trillion rubles within five days to finance the operation of the country's nuclear plants during the coming fall and winter.

Widespread Plant Protests. The year 1996 saw considerable unrest among the nuclear plant workforce. In June, workers at the Novovoronezh plant reportedly staged spontaneous protests demanding backwages for four months. The same month, Anatoliy Zemskov, head of public relations at Rosenergoatom, told the Interfax news agency that wages for staff at the Novovoronezh, Kola, Kalinin, Leningrad, Kursk and Smolensk nuclear plants had been delayed three to four months.

Workers at the Leningrad plant reportedly began protesting wage delays in June, which led to the resignation of the plant director in July. They resumed their protests—in the form of plant sit-ins following completion of normal shifts—in August, charging that Minatom had failed to maintain the scheduled payment of delayed wages under an agreement with the atomic workers trade union.

In August, workers at the Smolensk, Bilibino, Kalinin and Kola plants declared their readiness to dispute plant management over the wages issue. In late September, Rosenergoatom said that the non-payment of wages had produced a "critical" situation at some nuclear power plants. In mid-October, workers at the Smolensk and Kalinin plants staged brief, warning strikes. Workers at the Kursk, Kola and Novovoronezh plants were threatening to strike, but the strike did not materialize. As of February 1997, staff at the Novovoronezh and Kalinin plants had not been paid for three months.

Workers at a division of the company that carries out repairs at the Smolensk nuclear plant went on strike March 1, 1997 because they had not been paid in nine months. The plant's chief engineer reportedly said that the strike would not affect the operation or safety of Smolensk.

In April, representatives of the nuclear industry workers trade union picketed in Moscow, demanding payment of back wages. The same day, First Deputy Prime Minister Boris Nemtsov signed a protocol ordering that back wages be paid by mid-year.

July Protest March on Moscow. Employees of the Smolensk plant announced in June that they were prepared to strike over back wages. The following month, Moscow media reported that about 75 workers from the plant had begun a 250-mile protest march to Moscow. Along the route, they were reportedly joined by colleagues from the Kalinin, Kursk and Novovoronezh nuclear plants. In addition, employees of the Leningrad plant reportedly started on a march to Moscow to meet their Smolensk colleagues.

At a meeting in Moscow with Deputy Prime Minister Vladimir Bulgak on July 16, representatives of seven nuclear power plants signed a protocol on the allocation of money to pay plant workers. According to the protocol, 123 billion rubles will be allocated each month—starting in July—to pay nuclear plant employees. In the fourth quarter of 1997, this amount will be increased to 300 billion rubles.

According to the ITAR-TASS news agency, President Yeltsin summoned Russian Minister of Atomic Energy Viktor Mikhaylov to a meeting at the presidential residence July 17, where he reportedly told the minister that the wage arrears needed to be paid as soon as possible. Mikhaylov said they would be. The president also said that special attention should be paid to budget financing in the ministry.

First Deputy Finance Minister Aleksey Kudrin reportedly said in late July that the government would pay all back wages to the country's nuclear power plant workers by the end of the year. According to Kudrin, wages arrears totaled 123.5 billion rubles, of which the Ministry of Atomic Energy will pay 25 billion and RAO-YeES will pay 63 billion. He said that the government would sell some state-owned companies to raise the money.

Status of Liability Coverage

In early June 1995, the Duma—Russia's lower house—approved nuclear energy legislation that includes a provision nuclear liability. Russia's upper house—the Federation Council—approved the law in mid-June, but in August President Yeltsin's office rejected the law because of judicial discrepancies, sending it back to the Duma for reconsideration. In late October, the Duma again approved the law, noting that it had taken into consideration Yeltsin's remarks and suggestions. President Yeltsin signed the law in November 1995.

Under the law, the nuclear power plant operating organization is responsible for any damage caused by an accident at the plant. The type and limits of liability of the operating organization will be spelled out in separate legislation. According to the law, the maximum amount of liability in any single incident is not to exceed the amount specified in Russia's international treaties.

In May 1996, Russia signed the Vienna Convention, which ensures that the responsibility for damage caused by a nuclear accident is channeled to the plant operator. In December, President Yeltsin sent the convention to the Duma for ratification, but it has not yet done so. Although a law spelling out the type and limits of liability for the operating organization was drafted in 1995, the Duma has yet to enact such legislation.

Russia has asked for Western assistance in developing the nuclear insurance framework needed to support such legislation. The Organization for Economic Cooperation and Development's Nuclear Energy Agency and Russia's GAN jointly sponsored a seminar on nuclear liability and insurance issues in Moscow in April 1997. Russia's shortage of capital presents difficulties in setting up a Western style national nuclear insurance pool, according to some seminar participants.

Russia is not a party to the 1988 Joint Protocol on Civil Law Liability and Compensation for Cross-Boundary Damage from Nuclear Accident, which resolves potential conflicts between the Paris Convention—which covers 14 European countries—and the Vienna Convention—which has worldwide coverage.

Bilateral Agreements. In late 1993, Russia signed an agreement with the U.S. government that covered nuclear safety assistance activities and the provision of liability protection. The Russian government agreed to indemnify all U.S. government contractors working on safety-related improvements at Russian nuclear power plants.

Russia and the European Commission signed a memorandum of understanding on Feb. 27, 1995, that provides indemnity from nuclear liability for Western companies working on safety-related projects at Russian nuclear plants under the European Union's program. After work under earlier contracts was held up, however, Viktor Mikhaylov, head of Minatom, sent letters to major vendors and the European Commission in March 1997 confirming that Western companies would be protected from third-party claims for damage associated with work they had done under the TACIS program. European vendors considered the letter to provide sufficient coverage until Russia has a full nuclear liability system in place.

Russia and the European Bank for Reconstruction and Development (EBRD) in June 1995 concluded an indemnity agreement for work done under contract at the Kola, Novovoronezh and Leningrad plants that is being funded by the EBRD's Nuclear Safety Account. President Yeltsin issued a decree in August putting the agreement into effect.

Russia and Germany have been working since late 1994 on a bilateral indemnity agreement that would protect German companies supplying equipment to Russian nuclear plants.

Fuel Supply and Waste Disposal

Supply of Fuel. Following the breakup of the Soviet Union, some sectors of the nuclear fuel production complex were left outside Russia. Most of the uranium dioxide pellets for fuel assemblies, for instance, are produced in Kazakhstan, and Ukraine supplies zirconium for fuel rods. Russia has extensive uranium resources, but it has only one operating uranium processing facility. The country has four uranium enrichment plants and two major fuel fabrication facilities, the Elektrostal complex near Moscow and a plant in Novosibirsk. Fuel for VVER-440, RBMK, BN (fast breeder) and GBWR (Bilibino) reactors is produced at Elektrostal, and VVER-1000 fuel at Novosibirsk.

The Ulbinskiy plant in Kazakhstan produces fuel pellets for VVER-1000 and RBMK reactors, which are sent to Novosibirsk and Elektrostal, respectively, for insertion in fuel assemblies.

The fuel production cycle has been disrupted, however, by the inability of many Russian nuclear plants to pay for fuel. The Novosibirsk plant, for instance, was owed more than 70 billion rubles by plants in Russia and Ukraine in April 1994. As a result, it was unable to buy equipment and material needed for fuel production.

With some Russian nuclear plants—especially RBMKs—facing shutdown because of low fuel stocks, the Russian government decided in April 1994 to give the plants special credits to buy fuel.

According to a Russian news agency report in January 1995, Russian fuel manufacturers have been paid for only about 3-5 percent of the cost of fuel produced; they are reportedly owed 300 billion rubles by Russian nuclear plants. By May 1997, the Elektrostal plant alone was owed 400 billion rubles for fuel that it had provided to nuclear power plants and another 300 billion rubles for orders placed but not yet delivered.

The Russian Ministry of Atomic Energy is responsible for operating the country's nuclear fuel facilities.

Spent Fuel Storage and Disposal. The Ministry of Atomic Energy is solely responsible for handling spent fuel from Russia's nuclear plants. Spent fuel from the country's VVER-440 reactors and its breeder reactor is sent to RT-1, a reprocessing plant in Ozersk, formerly Chelyabinsk-65. The recycled uranium is used to produce fuel for RBMK reactors. At the end of 1995, RT-1 was 15 percent full, but according to a Minatom official the facility's client base was shrinking. As Russian VVER-440 reactors are decommissioned, said the official, Minatom would have to convince foreign clients to continue reprocessing spent fuel to ensure RT-1's continued operation.

In March 1997, one of the vitrification facilities at RT-1 was shut down because of a lack of money. Three months later, Minatom had reportedly begun talks with Eastern European nuclear plant operators on spent fuel reprocessing. The Czech and Slovak republics stopped sending spent fuel to RT-1 after the Soviet Union collapsed, and Hungary suspended and then resumed shipments. With the drop in shipments of spent fuel, plant throughput has fallen to 25 percent of design capacity.

VVER-1000 Spent Fuel. Spent fuel from VVER-1000 plants is stored either at the plant sites or at a facility near Zheleznogorsk, formerly Krasnoyarsk-26. As a result of a Russian-Ukrainian government agreement, about half the VVER-1000 spent fuel stored at the facility in the future will be from Ukrainian reactors. Even if VVER-1000 plants increase their on-site storage capacity for spent fuel, the Zheleznogorsk facility will be full by 2010.

A reprocessing plant for VVER-1000 spent fuel, known as RT-2, is under construction at Zheleznogorsk, but work has been delayed because of funding difficulties, and the facility is only about 25 percent complete. In September 1995, the Russian government approved new rules on reprocessing that would allow spent fuel from foreign reactors to be stored at Zheleznogorsk until RT-2 is completed. Fees from such storage could be used for the construction of RT-2. However, local opposition to the import of foreign fuel, on the grounds that it violates Russian law, reportedly led to a collapse of talks with Germany and Switzerland on the shipment of spent fuel to Zheleznogorsk. RT-2 may thus not be operational by its target date of 2005.

A Minatom official reportedly said in December 1995 that RT-2 was about 30 percent complete, and prospects for finishing it were bleak. Obstacles included a lack of funding—some of it to have come from foreign contracts—and difficulties anticipated in obtaining agreement on an ecological report needed to license the facility. However, according to an RT-2 spokesman, work resumed on the facility in April 1997. And in June, Minister of Atomic Energy Mikhaylov said the ministry would transfer at least $20 to the facility to finance construction.

Residents in the Krasnoyarsk area collected signatures for a referendum on banning construction of the facility, but in April 1997, the regional legislative assembly declined to hold a referendum.

RBMK Spent Fuel. Spent fuel from Russia's RBMKs is not reprocessed because it is considered unprofitable. Instead, the spent fuel is stored at the plant sites. Construction of a centralized long-term dry storage facility for spent RBMK fuel was planned, but has reportedly been postponed. As a result, on-site storage at RBMK plants is being expanded. The French company SGN/Reseau Aursys has been awarded a contract to build storage facilities at the Kursk and Smolensk plants.

Storage facilities at the Leningrad, Kursk and Smolensk plants are nearly exhausted, and spent fuel is being compacted in cooling and storage pools to increase the original design capacity, according to the Ministry of Atomic Energy in June 1997.

Imported Nuclear Waste. In addition to reprocessing spent fuel from its own VVER-440 reactors, Russia has accepted spent fuel from VVER-440 reactors in Eastern Europe for reprocessing.

In May 1994, the Russian government issued a decree on an environmental protection action plan for 1994-1995 that prohibited the import of radioactive waste. By defining spent fuel as a raw material, however, Russia's Ministry of Atomic Energy has continued to accept spent fuel from other countries. In June 1994, the lower house of Russia's parliament—the Duma—approved a draft law on handling radioactive waste that prohibited the import of nuclear waste into Russia. In November, the Duma reversed its position and, unable to support a complete ban on imported spent fuel, sent the draft law back to a parliamentary committee for revision.

In July 1995, the Russian government issued a decree on reprocessing spent fuel from foreign nuclear power plants. Under this decree, all radioactive waste from the reprocessed fuel must be returned to its country of origin after 20 years.

The country's new law on nuclear energy, signed by President Yeltsin in November 1995, codifies the Ministry of Atomic Energy's current practice of circumventing existing environmental legislation by defining spent fuel as a raw material. In late 1995, both houses of Russia's Parliament approved a law on radioactive waste that would ban the import of spent fuel by defining it as waste, not a raw material. But according to a report by Russian news agency ITAR-TASS in late December 1995, the bill was vetoed by President Yeltsin on the grounds that it contradicted the Russian constitution and statutes. Yeltsin reportedly pointed out in a letter to the Duma that the version submitted to him differed from that passed by the Duma.

In April 1996, the Russian Supreme Court overturned part of a January 1995 presidential decree on importing spent fuel. The court ruled that spent fuel could be imported in the future only if relevant international agreements, approved by environmental experts, had been signed. In essence, the court ruling reinstated some provisions of the radioactive waste law vetoed by Yeltsin. A Minatom official reportedly said that the ruling would not affect construction of the RT-2 facility.

Technical/Upgrading Activities

According to Rosenergoatom, IAEA-recommended safety improvements have been made to—or planned for—the first-generation RBMKs and VVER-440 Model V230s. Kursk Unit 1 was shut down in April 1994 for upgrading. Upgrading of Leningrad units 1 and 2 has been completed. Principal funding for the improvements made to these RBMK units has come from the European Union's TACIS (Technical Assistance to the CIS) program and the G-24 nations. Novovoronezh units 3 and 4 and Kola units 1 and 2 are also earmarked for upgrading.

According to a Rosenergoatom official, the company carried out $54 million worth of safety enhancement projects in 1996, consisting of $44 million in equipment supplied by Western companies, and $10 million in technology. The official said that Rosenergoatom is engaged in 12 international nuclear safety programs that require Russia to carry out 420 projects costing a total of $500 million.

International Cooperation/Assistance

Moscow WANO Center. The Moscow Center of the World Association of Nuclear Operators (WANO) continues to provide reports on plant operational events to the association. WANO-sponsored exchange visits also have continued.

IAEA Training Seminars. Although the International Atomic Energy Agency is known for its inspection missions—including its Assessment of Safety Significant Events Team (ASSET) missions—to nuclear power plants, the agency also conducts ASSET training seminars at a country's request. The seminars are designed to train operators and regulators in the use of the ASSET methodology to identify safety issues, to assess their consequences and to eliminate the root causes of likely future accidents and incidents.

Before the collapse of the Soviet Union, the U.S.S.R. Ministry of Atomic Power and Industry requested an ASSET seminar. The seminar, held Oct. 14-18, 1991, in Kiev, was attended by 33 people representing 14 Soviet nuclear power plants, MAPI, the Soviet regulatory body and nuclear power research centers. Included in the seminar was a discussion of the compatibility of the ASSET methodology and the recently adopted U.S.S.R. regulations on investigating operational events. In addition, ASSET training missions visited the Balakovo plant (Aug. 30-Sept. 3, 1993), the Kalinin plant (Feb. 15-17, 1994) and the Smolensk plant (June 6-10, 1994).

U.S. Assistance Program. Under this program, the U.S. government is helping to improve the safety of Soviet-designed nuclear plants in Russia as well as Ukraine and Eastern and Central Europe. The program covers operational safety improvements, risk reduction and regulatory assistance (see the sections on **NRC Programs**, **DOE Programs**).

European Union Assistance. Under its TACIS program, the EU has funded projects involving safety systems upgrade work, radioactive waste management, emergency procedures, precise measurement technology and training at VVER plants in Russia and Ukraine. Projects that have been completed include: providing a data package and set of description systems for developing a VVER-440 Model V230 simulator; providing training procedures and materials for VVER-440 Model V230 staff; and developing a methodology for drafting, checking, reviewing, validating and using all operating procedures. During 1997, Russia expected to received $24 million under the TACIS program, according to a Rosenergoatom official. (For details of this assistance, see the **International Assistance** section.)

EBRD Nuclear Safety Account. In June 1995, Russia agreed to accept grants totaling 76 million ECU ($80.5 million) from the European Bank for Reconstruction and Development's Nuclear Safety Account for upgrades at three plants: Leningrad, Novovoronezh and Kola. In accepting the grants, Russia agreed to several conditions, including an assessment of the need for continued operation of the first generation VVER-440 Model V230 and RBMK reactors at these sites.

Of the total grants, 30.6 million ECU ($32.4 million) were earmarked for the Leningrad plant, which has four RBMK reactors. Projects were expected to include inspection and monitoring, non-destructive examination, fire protection, and components for emergency core cooling system upgrades.

A grant of 44.9 million ECU ($47.5 million) was designated to Rosenergoatom for joint projects at the Kola plant, with four reactors, two of them Model V230s, and the Novovoronezh plant, with three reactors, two of them Model V230s. Activities at these plants were expected to include inspection and monitoring, replacement valves, and fire and radiation protection. Of the 44.9 million ECU, about 20 million ECU ($21.2 million) were earmarked for the Kola plant, to be used for replacement of steam generator safety valves, reconstruction of the emergency feedwater system, erection of an emergency control room and major improvements in the instrumentation and control system.

All projects were slated for completion by the end of 1997, but in May 1997 both sides were working on an agreement to extend the completion date to the end of 1998. That same month, NSA officials cancelled some equipment intended for Leningrad units 1 and 2 and Kola units 1 and 2 because of major delays in the project.

In addition, the regulatory authority GAN would receive 900,000 ECU ($954,000) to use in establishing a full licensing regime for Russia's RBMKs and VVER-440 Model V230s. The grant agreement stipulated that the new system be used to evaluate whether these plants should be shut down or permitted to operate for a limited period. The new licensing procedures are expected to come into force in mid-1997. All of these first-generation units operate under a special system that includes an annual operating license issued by the regulatory authority GAN.

A consortium of experts from France, Germany, the United Kingdom, Russia and the United States has been awarded a 900,000 ECU ($954,000) contract to review the short-term safety upgrades at Leningrad units 1-4, Kola units 1-2 and Novovoronezh units 3-4.

Kursk units 1 and 2—both first-generation RBMKs—were not included in the NSA-funded safety upgrades. But under the 1995 NSA agreement, Russia agreed not to restart Kursk 1—shut down for backfits and replacement of some fuel channels—before 1998, and only if new licensing procedures were in place and an in-depth safety assessment had been carried out. The U.S. Department of Energy launched the safety assessment in March 1997.

Joint Japanese and Russian Efforts. As part of its effort to support improvements in Russian plant operations, Japan has entered a joint program with Russian counterparts to develop a warning system for leaks in piping. In addition, as part of a 1993 cooperation agreement, Japan built a simulator for the Novovoronezh plant.

Canadian Support. In May 1992, Canada signed a memorandum of agreement with Russia. The agreement allows Canada to assist with a full range of nuclear technology-related projects, including RBMKs, fuel cycle efforts, nuclear heating units, waste technology and decommissioning. Nuclear applications in medicine and agriculture are also included. In June 1992, Canada announced it would commit Canadian $30 million ($21.7 million) for a nuclear safety initiative aimed at improving Russian plant safety. In early 1993, Canada announced that it would establish the Canada-Russia Nuclear Safety and Engineering Center, with offices in Moscow and Sosnovyy Bor, near the Leningrad plant. Canada is also talking with Russia about the feasibility of building two 700-megawatt CANDU reactors near Vladivostok in eastern Siberia.

Leningrad PSA Project. Based on the work done for the Barselina project at Lithuania's Ignalina 2, Western experts reached agreement with officials from Russia's Research and Development Institute of Power Engineering—the design institute for RBMKs—and the Leningrad plant on conducting a similar probabilistic safety analysis (PSA) at Unit 2 of the Russian plant. Data collection for a Level 1 PSA began in March 1997 and the project is expected to be completed in September 1998.

Nuclear Incident Exercises. In May 1995, Russia conducted an exercise to test the readiness of its agencies responsible for transmitting information on nuclear incidents and accidents. For the exercise, Russian authorities simulated a severe loss-of-coolant accident at the Kola nuclear power plant. The exercise, held in the Murmansk region, involved observers and participants from several countries and international organizations. According to the participants, the exercise demonstrated that surrounding populations could be evacuated in the event of an accident, and that alternative communications could be established to ensure that information was available after an accident.

In December 1995, Russian emergency workers carried out an exercise at the Leningrad nuclear plant to test their ability to deal with contamination from a nuclear accident. The exercise was observed by nuclear experts from several foreign countries.

SWISRUS Project. As part of an ongoing project to transfer modern nuclear safety analysis methods to Russian nuclear facilities, and to assess the need for backfitting measures at these facilities, the Swiss nuclear safety authority HSK is conducting a probabilistic safety analysis at Russia's Novovoronezh 5 plant.

Cooperative Agreements, Joint Ventures

Russian-Cuban Project. In 1976, the Soviet Union and Cuba agreed to build a nuclear plant near Cienfuegos in Cuba. Construction of the Juragua plant—two VVER-440 Model V318s (a version of the Model V213 that the Soviets planned to export)—was begun in 1983 but halted in 1992 following the collapse of the Soviet Union and a lack of Cuban funding. In 1993, Russia reportedly extended a loan to Cuba to finance the maintenance of buildings and equipment at the site.

In 1995, Russia sought to revive the project. Officials of Germany's Siemens said in May that the company had been asked by Russia to supply instrumentation and control (I&C) equipment for the Cuban plant under a Russian-German joint venture set up in 1994. According to a Russian atomic energy ministry spokesman, Russia granted Cuba $30 million in credit in 1995 to purchase auxiliary equipment for the plant.

A Cuban official said in August 1995 that four Western companies had nearly completed a financial and technical feasibility study of the plant's completion. Later in the year, a Cuban deputy minister reportedly said that the study had shown the project to be viable.

Russian officials visiting Cuba in October 1995 reportedly agreed to contribute $349 million to plant construction, with Cuba providing $208 million and the remainder to be raised from other sources. A Russian atomic energy ministry official said in November 1995 that an international consortium would be established in the first quarter of 1996 to build the plant, and that construction would be resumed in the first half of 1996.

In October 1996, Russia extended the period during which Cuba could use the $30 million credit to the end of 1997. In mid-January 1997, Cuban President Fidel Castro reportedly said there was no hope that the plant would be completed. But a Russian delegation visiting Cuba in late January agreed to help Cuba finish the plant. According to the delegation, construction will be resumed in August, and the first unit could come on line in 3.5 years, paying back the Russian investment through income from electricity produced over seven years of operation.

Construction of Unit 1 is estimated to be more than 90 percent complete, while Unit 2 is estimated to be 20-30 percent complete. The cost of completing Unit 1 is estimated at between $300 million and $750 million, putting the total cost of completing the plant at more than $1 billion. Russian Atomic Energy Minister Mikhaylov said in June 1997 that Russia might lend Cuba $200 million to $300 million for the project.

Russian-Iranian Agreement. The Ministry of Atomic Energy signed an $800 million agreement with Iran in 1995 to complete the construction of a 1,000-megawatt pressurized water reactor at Bushehr, where work was suspended by Germany in the wake of the overthrow of the Shah in 1979. According to Minatom, Russia would help to operate the plant for two years. Russia has also proposed to build three additional reactors—a VVER-1000 and two VVER 440s—at the Bushehr site. It will reportedly supply fuel for the reactors and take back spent fuel for reprocessing.

Financing problems and the lack of technical documentation for the German-made equipment already installed at the site have delayed the project. Russian specialists have carried out engineering studies at the site, which have identified problems in matching VVER equipment to the German equipment already supplied. Experts from the International Atomic Energy Agency visited the site in 1995 to review the project, making several recommendations on seismic conditions. Because of the technical problems, Russia had not agreed to a completion deadline. In early January 1997, an Iranian nuclear official reportedly said that the first unit at Bushehr would be completed in three years, but Yuriy Vishnevskiy, head of Russia's regulatory authority GAN, said in July that the plant would begin operating in five to six years.

Also in July, GAN and the Iranian atomic energy organization signed an agreement on ensuring the safety of the Iranian plant. Under the agreement, staff from GAN and the Iranian organization will analyze the plant design. In addition, Russian officials will inspect the Russian equipment and supervise construction.

Sino-Russian Agreement. In a memorandum of understanding signed in December 1992 by the Russian and Chinese governments, China agreed to buy two 1,000-megawatt reactors of the new VVER design. In late 1995, Russian officials reportedly said that differences over contractual arrangements were delaying the project.

In March 1996, a Chinese official reportedly said that Russia had offered China a $2 billion low-interest loan for the reactors An official of the Chinese Nuclear Society said in April that the two sides had agreed that the instrumentation and control (I&C) systems would be supplied by a third party. The same month, Russia and China signed a cooperative agreement on nuclear energy that included the joint development of nuclear power plants in China.

In November 1996, a Chinese official said the site of the proposed Russian-made plant would be moved south to a site closer to the country's rapidly growing population centers. In December, China announced that the plant would be built near Lianyungang, a port city in eastern Jiangsu province.

Following a visit by Chinese Premier Li Peng to Russia in December, the two countries agreed on a draft contract for the nuclear plant. Under the agreement, China will carry out the construction work, and Russia will be responsible for design, equipment supply and primary circuit welding. The draft contract also gives the Chinese Nuclear Energy Industry Corp. an option to buy four additional reactors. Russia and China signed a contract in May 1997 for the two units, which are expected to start operating in 2004 and 2005, respectively.

Russia is also negotiating an agreement with China under which Russian specialists would train Chinese reactor personnel and supply a full-scope VVER-1000 simulator and plant operation procedures.

Russian-Indian Agreement. In late 1994, the Ministry of Atomic Energy agreed to build a 2,000-megawatt nuclear power plant using Russian VVER technology at Kundamkulam in India. The eight-year construction project was expected to begin in 1995. Russia agreed to accept spent fuel from the plant for reprocessing. However, Russia's Ministry of Foreign Affairs reportedly approved the sale on the condition that India adhere to full-scope IAEA safeguards. To date, India has not done so.

In October 1995, India and Russia signed a memorandum of understanding—an addendum to the 1994 agreement—on the construction of the nuclear plant. But in December 1995, Russian atomic energy ministry officials reportedly said that India no longer wanted a turnkey VVER plant and instead wanted to build the plant itself. According to the officials, Russia would not proceed with the project until it was assured that India could pay for the project.

In October 1996, India resumed negotiations with Russia on the plant. An Indian official reportedly said that terms had to be negotiated anew, and that India wanted the plant on a turnkey basis. The reactors would be the VVER-

92 design, according to a Russian news service. Once a contract is signed, two years of feasibility and design studies would be required before construction could begin, a Minatom official said in November. In January 1997, Russian Atomic Energy Minister Mikhaylov said a contract would be concluded before the end of the year. He added that financing was delaying the project, but Russia hoped to be able to offer some credit to India. According to Mikhaylov, financing problems had yet to be resolved as of June 1997.

Special British, German Projects. In December 1992, British and German government organizations initiated two projects. One is designed to assist Russian authorities in controlling nuclear materials. The second project involves the construction of radioactive waste treatment facilities at the Balakovo plant.

French-Russian Agreements. French and Russian authorities have continued to set up cooperative arrangements. One agreement between French authorities and Russia's Minatom will allow for the establishment of a series of "twinning" arrangements between Russian and French plants to promote the exchange of information on plant experience. Another agreement between Minatom and the French company Cogema allows for joint projects toward managing the nuclear fuel cycle. In March 1993, Minatom and the French Atomic Energy Commission signed an agreement that set in place the framework for cooperative work in such areas as reactor operations, the nuclear fuel cycle, plant decommissioning, safety, research, public information and training.

According to an Electricité de France official, the French utility company has signed five contracts worth FF 30 million ($4.7 million) with the Russian Ministry of Atomic Energy under a 1995 cooperative agreement, and is carrying out work on nine contracts worth FF 93 million ($14.8 million) with Rosenergoatom aimed at improving safety controls at the Kalinin, Beloyarsk, Novovoronezh, Leningrad and Balakovo plants.

Under an intergovernmental agreement, France in 1997 approved the allocation of $24.5 million for safety enhancement projects at Russia's nuclear plants, according to a Rosenergoatom official. The money is to be disbursed over two-three years.

Franco-German Safety Office. GRS and IPSN, the German and French technical consulting bodies for nuclear safety, respectively, have formed a joint venture—Riskaudit—to support EU-funded safety-related activities. The two organizations have opened an office in Moscow for the joint venture.

Satellite Link with Nordic Countries. Satellite communications links were established to provide Finland, Sweden and Norway with information on operating events at the Leningrad plant. Plans are to link the Kola plant as well.

Converting Weapons to Fuel. In early 1993, the United States and Russia reached agreement on the disposition of highly enriched uranium (HEU) from Soviet nuclear weapons. Under the agreement, Russia is converting HEU to low enriched uranium, which is being purchased by the United States Enrichment Corp. for use in commercial nuclear power plants. Over the course of the 20-year agreement, Russia will deliver low-enriched uranium derived from 500 metric tons of HEU. The Russian government has agreed to use some of the money earned from sales to improve the safety of its nuclear power plants.

Minatom-General Atomics Agreement. In 1993, Minatom and the U.S. company General Atomics signed a memorandum of understanding, whereby they will cooperate in designing and developing a gas-turbine modular helium reactor that would use weapons plutonium as fuel. In February 1995, the two sides agreed to invest $1 million each in the project. In September 1996, DOE approved the transfer of General Atomics' technology to Russia for the design and development of the reactor. In addition to General Atomics and Minatom, France's Framatome is also participating in the project. Current plans call for a prototype to begin running by 2005.

Minatom-Siemens Agreement. In 1994, Minatom and Germany's Siemens set up a joint venture company to manufacture Siemens' instrumentation and control (I&C) systems for use in Russia and to design new I&C systems. In November 1995, Siemens signed a letter of intent to supply engineering services and I&C systems for a prototype 640-megawatt VVER reactor to be built at the Leningrad plant site beginning in 1997. In payment, Minatom will provide DM 15 million ($8.04 million) worth of enrichment services annually for the first five to six years of the project to the German utility Bayernwerk, which will then pay Siemens.

Russian-Czech Agreement. Russia and the Czech Republic signed an agreement in 1994 to cooperate in the field of nuclear power engineering. Under the agreement, Russia will deliver fresh fuel to the Czech Republic and will reprocess spent fuel.

Russian-Brazilian Agreement. In September 1994, Russia and Brazil agreed to cooperate in the peaceful use of nuclear energy. One area of cooperation is nuclear safety. During talks in April 1995, the two sides considered the construction of small nuclear power plants in Brazil using low-capacity Russian reactors like those used on icebreakers.

Russian-Hungarian Agreement. In March 1995, Russia and Hungary agreed on a means of clearing the former Soviet Union's debt to Hungary that included the delivery of Russian gas or coal to Ukrainian electric power plants and the delivery of electricity from Ukraine to Hungary.

Russian-German Project. Under a joint program to monitor radiation levels around Russian nuclear plants, observation posts have been set up at the Smolensk plant. Equipment for similar posts has been delivered to the Balakovo, Beloyarsk, Kalinin and Kursk plants, but not yet assembled because of financing problems.

U.K.-Russian Agreement. In September 1996, Russia and the United Kingdom signed an agreement on nuclear cooperation addressing such issues as nuclear safety, nuclear waste management and the nuclear fuel cycle.

Russian-Canadian Agreement. In April 1996, Canada and Russia signed a memorandum of understanding on the peaceful use of nuclear energy. Under the agreement the two countries will carry out several joint projects.

Russian-Armenian Loan Agreement. Under an agreement signed in August 1996, Russia will extend a 100-billion ruble loan to Armenia to ensure the safe operation of the Armenian nuclear power plant and to buy nuclear fuel.

Inspections

At the request of the former U.S.S.R. and subsequently the Russian Federation, the International Atomic Energy Agency has inspected operating plants and those under construction. The IAEA's missions to Balakovo, Kalinin, Kola, Kursk, Leningrad, Novovoronezh and Smolensk are discussed in the separate summaries of those plants.

Operating Russian Nuclear Plants

Plant	**Type/Model**	**# Units**	**MWe (net)**
Balakovo	VVER-1000	4	3,800
Beloyarsk	Fast Breeder	1	560
Bilibino	Light Water-Cooled, Graphite-Moderated Reactor	4	44
Kalinin	VVER-1000	2	1,900
Kola	VVER-440 Model V230 (two) VVER-440 Model V213 (two)	4	1,644
Kursk	RBMK-1000	4	3,700
Leningrad (Sosnovyy Bor)	RBMK-1000	4	3,700
Novovoronezh	VVER-440 Model V230 (two) VVER-1000 (one)	3	1,720
Smolensk	RBMK-1000	3	2,775
TOTAL:		29	19,843

BALAKOVO NUCLEAR POWER PLANT

Type: VVER-1000

Units: Four

Total megawatts (net): 3,800 (950 per unit)

Location: Balakovo, Saratov (Russian Federation)

Dates of initial operation:

Unit 1 - May 1986
Unit 2 - January 1988
Unit 3 - April 1989
Unit 4 - December 1993

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Operating History

On March 4, 1992, an electrical equipment fire forced the shutdown of Unit 3. According to the European Nuclear Society, automatic systems shut the plant down, and plant personnel had the fire under control in 40 minutes.

There were reports in the Russian press in 1992 about safety-related problems, some of them serious, at the Balakovo plant.

Technical/Upgrading Activities

A number of upgrades have occurred or are under way at Balakovo:

- Damaged thermal insulation on containment equipment was repaired to help prevent strainer clogging.
- A linear position indicator has been installed on the control rod.
- Power supply cables are being replaced with fire-protected ones.
- The automated fire extinguishing system is being upgraded.

Additional Plans

In February 1992, Russian authorities stated their intentions to complete an additional unit at Balakovo. Work began in 1984, and Balakovo 4 was commissioned in May 1993 and began commercial operation in December 1993. It was the first unit to be completed under Russia's 20-year nuclear construction plan announced in 1992 and the first unit to go on line since the breakup of the Soviet Union.

Under the United States' nuclear safety assistance program, Russia's first nuclear training center is to be located at Balakovo.

International Exchange/Assistance

In 1993, Electricité de France and Cogema were awarded a contract under the European Union's TACIS program to help set up two nuclear public information centers in Russia. One of the centers will be located at the Balakovo plant.

In October 1994, 1.5 million ECU ($1.6 million) worth of steam generator cleaning equipment was delivered to the Balakovo plant under the EU's TACIS program.

The German company Nukem has agreed to build a nuclear waste treatment center at the Balakovo plant. The equipment to treat the waste will cost DM 23.5 million ($12.5 million), with the plant paying part of the cost. Germany's Siemens has a contract to supply loose parts, vibration, and acoustic leak monitoring systems to Balakovo. Germany is also providing upgraded telecommunications and radiophone gear to improve normal and emergency operations.

Other European Assistance. The EU is developing a quality assurance program and appropriate training for Balakovo. An integrity assessment of reactor pressure vessels, including embrittlement aspects, is also ongoing. Water chemistry equipment and sensors for automatic fire protection are being provided.

IAEA Training Seminar. Although the International Atomic Energy Agency is known for its inspection missions—including its ASSET missions —to nuclear power plants, the agency also conducts ASSET training seminars at a country's request. The seminars are designed to train operators and regulators in the use of the ASSET methodology to identify safety issues, to assess their consequences, and to eliminate the root causes of likely future accidents and incidents.

An ASSET seminar was held at the Balakovo plant Aug. 30-Sept. 3, 1993. A seminar demonstrating the practical use of ASSET analysis procedures was held at the plant Feb. 4-6, 1997.

WANO Exchange Visits. The World Association of Nuclear Operators has sponsored several exchange visits involving the Balakovo plant. The plant has hosted personnel from the following plants or organizations:

- Sweden's Nuclear Training and Safety Center (August 1992),
- Spain's Trillo plant (February 1993),
- Japan's Genkai plant (August 1993),
- United States' San Onofre plant (September 1993),
- France's Paluel plant (January 1994),
- South Korea's Ulchin plant (October 1996).

In addition, personnel from Balakovo have visited the following plants or organizations:

- Spain's Trillo plant (February 1992, March 1994),
- Sweden's KSU (May 1992, May 1993),
- Japan's Genkai plant (November 1993),
- United States' San Onofre plant (November 1993),
- United States' Beaver Valley plant (June 1994),
- United States' Diablo Canyon plant (November 1994),
- United States' Wolf Creek plant (October 1995, October 1996),
- Brazil's Angra plant (February 1996),

Plant Twinning. The Balakovo plant is twinned with France's Paluel 3 and 4, with Germany's Biblis plant and with the U.S.'s San Onofre plant.

Under the Balakovo and Biblis twinning arrangement, a Western-style quality assurance program is being developed for Balakovo. In addition, the Biblis plant helped to install condenser cleaning equipment at Balakovo in 1994. Biblis staff are also helping Balakovo to analyze secondary-side water chemistry.

Under the auspices of WANO, Biblis and Balakovo staff have met each year since 1990 to discuss such issues as simulator training, outage management, and the start-up of Balakovo Unit 4.

U.S. Assistance. Under the U.S.'s International Nuclear Safety Program, Westinghouse Corp. has expressed interest in supplying a safety parameter display system for Balakovo, one of five safety upgrades reportedly requested by the plant. The Department of Energy and its U.S. contractors have worked with Russian personnel to set up a training center at Balakovo. For details of U.S. assistance, see the section on **DOE Programs**.

Inspections

ASSET Mission. In February 1992, Russian leaders formally requested the IAEA to send an ASSET (Assessment of Safety Significant Events Team) mission to the plant.

An ASSET mission visited Balakovo Oct. 5-16, 1992, to examine the effectiveness of the plant's policy for preventing incidents and review 14 reactor-years of operating experience. The team found plant management to be highly qualified and plant staff to be knowledgeable and dedicated to the primary safety objective of preventing accidents. The team also noted that plant management had improved plant performance with respect to safety and availability.

According to the team, effectiveness in preventing safety-significant events had sharply improved, and the team was satisfied that most of the corrective actions carried out by plant personnel had been appropriate.

However, the team identified two pending safety issues: undue challenges to the safety systems because of the poor reliability of instrumentation and control equipment, and inappropriate actions by personnel because of a lack of procedural support. The team offered an action plan that included recommendations to plant management on addressing instrumentation and control aging problems, making operating and maintenance procedures user friendly, and improving the effectiveness of operating experience feedback by paying more attention to human factors.

The team said that a follow-up ASSET mission in two to three years, to assess the progress made in accident prevention, would be advisable.

Follow-Up ASSET Mission. At the request of Rosenergoatom, a follow-up ASSET mission visited Balakovo Sept. 5-14, 1994. The team noted that the 14 recommendations made by the 1992 mission had been given high consideration by plant management. According to the team, systematic implementation of the ASSET process by plant staff had resulted in substantial improvements in plant safety and reliability over the two-year period. The team cited as examples the reduction in the number of unplanned shutdowns per reactor year—6.3 in 1991, 3 in 1992, 2 in 1993 and 0 as of September 1994—and in safety significant events per reactor year—from 1.1 in 1992 to 0.5 in 1994.

The team reviewed 215 events that had occurred at the four units since 1992. Of the 103 safety-relevant events, four were classified as Level 1. The rest were Level 0 on the International Nuclear Event Scale.

The team also identified five pending safety problems:

- Potential for radioactive release during fuel handling because of field operator errors,
- Lack of reliability of safety-related systems because of inadequate maintenance procedure and personnel proficiency,
- Degradation of the “control of reactor power” safety function because of control rod insertion delays,
- Lack of reliability of fire-fighting systems because of electronic component failures, and
- Challenge to reactor safety systems because of electrical/electronic component failures.

According to the team, these problems are related to a degradation of the plant’s defense in depth, but have not resulted in any measurable on-site or off-site safety consequences to date. The most important pending safety problem is that of the control rod insertion delay, said the team. The problem is being treated seriously by the plant, but requires additional financial support.

The pending problems can be reduced by doing more to improve maintenance procedures, replace degraded equipment, make design improvements and raise personnel qualifications.

ASSET Mission. An ASSET peer review mission visited Balakovo June 3-10, 1997. The mission reviewed Balakovo's self-assessment of its operational safety, carried out on the basis of the operational events—reflecting safety performance, safety problems and safety culture—that have occurred at the plant over the 1994-1996 period.

The ASSET mission found from the plant self-assessment that a few safety issues had not been completely eliminated—control rod insertion times, corrosion of upper head flanges, load transients, safety system instrumentation and control, and maintenance personnel proficiency. The action plan prepared by the plant addresses the safety issues and includes appropriate corrective actions.

The ASSET mission concluded that:

- The defense-in-depth provisions made by plant management in the hardware areas appear to have complied with the primary intent—the prevention of incidents and accidents. However, a more challenging review could have been beneficial in the software area—procedures and personnel.
- The events that occurred over the three-year period have highlighted the vulnerability of plant provisions in the areas of qualification of maintenance personnel and vigilance of operating personnel.
- The plant's self-assessment provides evidence of the progress made in the plant's ability to identify its safety issues, assess their importance and learn the lessons.
- The ASSET has highlighted some additional lessons that can be learned from the pending safety problems and has offered recommendations to complement the plant's action plan in the areas of safety qualification of specific procedures and specific category of maintenance personnel and in the area of safety culture for timely identification of problems and their prompt elimination.
- Balakovo's technical director is encouraged to require plant staff to carry out an annual self-assessment of operational safety performance, which should be reviewed at the site or at company level by an independent group.

BELOYARSK NUCLEAR POWER PLANT

Type: Fast Breeder Reactor

Units: One

Total megawatts (net): 560

Location: Zarechniy, Sverdlovsk, Russian Federation (site of the first two commercial RBMK reactors, which no longer operate)

Date of initial operation: November 1981

Design Characteristics

The sole operating unit at Beloyarsk, the BN-600, is a sodium-cooled breeder reactor that generates new fuel as it operates.

- BN-600 is a three-loop “pool” design, meaning that the major components—such as the reactor and recirculating pumps—are submerged in a large pool of liquid sodium.

- BN-600 is the second-largest breeder reactor in the world, behind the French Super Phenix.

- The plant features a modular steam generator design that allows the steam generators to be repaired while the plant is on line.

- Beloyarsk has no overhead containment structure; a standard industrial building and a protective shroud cover the reactor.

Operating History

According to reports in 1990, BN-600 has posed no major problems and has produced 35 billion kilowatt-hours at a cumulative capacity factor of 66 percent during its first 10 years of operation. In 1993, BN-600 produced 4.2 billion kilowatt-hours of electricity with a capacity factor of 80.3 percent.

Prior to commercial operation, the plant experienced early problems with leaking fuel and steam generator tube breaks resulting from faulty welds. (In breeder reactors, liquid sodium is used to transfer heat away from the reactor to manufacture steam. Volatile sodium/water interactions have occurred as a result of tube breaks in the steam generator.)

In December 1992, radioactive water from the liquid radwaste storage tank was spilled during transfer and seeped into the plant cooling pond. The incident was classified as Level 2 on the International Nuclear Event Scale (INES).

In October 1993, the plant was shut down following a sodium leak in an auxiliary system. A small fire occurred in a cleanup circuit for the primary sodium. The incident was classified as Level 1 on the INES. In November, the plant was shut down after an increase in radiation levels was detected in the exhaust fan system. The problem was traced to a sodium leak from one of the auxiliary cooling systems. The incident was classified as Level 1 on the INES.

In May 1994, a fire broke out at the plant, which was shut down for repairs at the time. Sodium from the secondary circuit piping leaked and caught fire on contact with air. The incident was classified as Level 1 on the INES.

In July 1995, a sodium leak from one of the reactor's secondary circuits caused a shutdown of the unit for about two weeks.

International Exchange/Assistance

WANO Exchange Visits. Under the auspices of the World Association of Nuclear Operators, the Beloyarsk plant hosted a visit of personnel from the Japan Atomic Power Company in June 1994, and Beloyarsk staff visited the Japan Atomic Power Company and the Monju reactor in October 1994.

Personnel from Beloyarsk visited the United States' Plant Hatch in March 1996.

Plant Twinning. The Beloyarsk plant is twinned with France's Creys-Malville plant.

Inspections

In 1986, the Soviet government added BN-600 to its list of nuclear facilities subject to inspections by the International Atomic Energy Agency (IAEA).

The Breeder Reactor Program: Then and Now

The first Soviet breeder reactor, an experimental 200-kilowatt unit, began operating in 1956 at the research and design center at Obninsk. The reactor was eventually upgraded to a 10-megawatt model.

A 135-megawatt breeder, BN-300, has operated since 1972 in Kazakhstan at Aktau (formerly Shevchenko) on the Caspian Sea. The unit also desalinates about 80,000 tons of water each year for the city of Aktau. The plant was troubled by a sodium/water reaction in 1975 that resulted in a two-hour sodium fire.

The Soviets began work on a larger breeder reactor, BN-800, at the Beloyarsk site. According to 1990 reports, work on the unit had slowed to a near halt. In its 20-year nuclear plant construction plan, announced in December 1992, the Russian government called for completion of the BN-800 reactor after the year 2000, as well as the construction of three BN-800 units at the South Urals site by 2000. But in December 1995, an atomic energy ministry spokesman reportedly said that two BN-800s would be built at the site sometime after 2000.

Beloyarsk plant management reported in June 1997 that GAN, the Russian nuclear inspectorate, had approved the construction of a BN-800 at the site, provided some required changes are made in the plant's design. Construction of the unit, which is estimated to cost $1 billion, is to be financed by Rosenergoatom, the Sverdlovsk regional administration and two Russian energy companies. Construction of the unit, which is now reportedly 8 percent complete, is expected to be resumed in 1998 and be finished by about 2005.

July 1997

BILIBINO (BILIBINSKAYA) NUCLEAR HEAT AND POWER PLANT

Type: Light-water cooled, graphite-moderated reactors

Units: Four

Total Megawatts (electric - net): 48 (12 per unit)

Location: Bilibino, Chukotka, Russia

Dates of initial operation:
Unit 1 - January 1974
Unit 2 - December 1974
Unit 3 - December 1975
Unit 4 - December 1976

Principal Strengths and Deficiencies

Each reactor in the reactor compartment is within its own vault with reinforced concrete walls. The common reactor hall lacks biological shielding.

The type of reactor at the Bilibino plant differs from the RBMK reactor. (Plant officials reportedly said a more apt comparison could be made to the Beloyarsk system than to the Chernobyl reactors.) The fuel design—characterized as “tubular” rather than rod-type elements—and uranium enrichment are not the same as for the RBMK reactor. The fuel presently used is uranium dioxide. The Bilibino reactors contain only about 4 percent as much fuel as the Chernobyl reactors. Fuel cladding is stainless steel.

Other available information indicates that the main material in the primary system piping is a stainless steel with 18 percent chromium, 10 percent nickel and 0.1 percent carbon composition. Monitoring of material performance is accomplished through borescoping, visual examination when piping systems are opened for maintenance, coupons for corrosion rate measurements, and measuring iron concentration rates by the analytical laboratory.

Water for the Bilibino plant comes from a pond created by a dam built at the same time as the plant in the Ponneurgen River valley. The water storage capacity is said to be quite limited. A closed-circuit technical water supply system was thus developed. Heat exchangers were designed and fabricated in Hungary. This system is said to be advantageous because it has a negligible thermal influence on the environment. However, it also reduces the efficiency of the thermodynamic cycle at some times of the year and involves additional power costs in some instances.

Operating History

Seventy percent of the energy produced by the Bilibino plant is provided for the mining industry and Pevek seaport, which is connected to the plant by a 300-mile transmission line. It is a cogenerating facility; each of the four reactors has a thermal capacity of 62 megawatts in addition to the 12 megawatt per unit electrical capacity.

A paper presented at a seminar in Canada in 1990 said the installed capacity utilization factor of the Bilibino plant for the previous 10 years was 84 percent and the availability factor was 90-91 percent.

An emergency shutdown occurred at the plant in March 1996. Unit 3 was switched off following detection of a leak in a pipe weld.

Maintenance staff was not reporting to work in the late summer of 1996 because of unpaid wages. Plant operators—who themselves were just being paid for work performed in June—were said to be covering for the maintenance staff.

Additional Plans

With an expected service life of 30 years, the Bilibino reactors have target closure dates between 2002 and 2006.

The regional government plans to build three more cogenerating nuclear units. The new units would each be 32-40 megawatts in capacity and similar in design to the current plant, but reportedly would include containment structures. They would become operational between 2001 and 2006.

The Russian Ministry of Atomic Energy is also studying the potential for towing floating nuclear units to the region (see **Nuclear Energy in the Russian Federation**, page 95).

Technical/Upgrading Activities

A 1994 report stated that installation of automatic radiation monitoring equipment was to be completed by or during 1996.

Design and planning for improvements in such areas as fire safety, plant safety, waste management and decommissioning were initiated, but stopped due to lack of funds.

International Exchange

Plant Twinning. The Bilibino plant is twinned with Germany's Würgassen plant.

1993 U.S. Visit. Eleven federal (including Nuclear Regulatory Commission and Environmental Protection Agency representatives) and state officials from the United States visited the Bilibino plant August 4-8, 1993. The visit was arranged at the request of Alaska Governor Walter Hickel through the Northern Forum, which includes Chukotka Governor Alexander Nazarov. Funding for the visit came from the U.S. Office of Naval Research.

The visit's purpose, according to the trip report, was to open communications and build preparedness arrangements so that any problems arising from Bilibino's operations could be addressed. "No attempt was made to assess ... safety of the plant or of its operations," the report said.

Findings of the team included:

- The Bilibino plant, plant management said, does not meet the most recent upgraded Russian safety standards for nuclear power generating facilities.

- At least $16 million is required for upgrades needed to bring the plant up to Russian safety standards. The primary deficiencies are in the areas of fire protection, radiation monitoring, communications and waste management.

- Plans for decommissioning of the plant's older units, plant expansion and replacement units have been delayed indefinitely because of economic uncertainties. The same uncertainties have affected completion of waste management plans.

- Plant staff is well-qualified, but lacks resources to make needed changes.

Recommendations. Among the team's recommendations were that a means be established for ensuring reliable communications of the plant with regulators in Moscow and with other potentially affected members of the Northern Forum. State officials from Alaska said they would work to identify sources and methods for providing the funds necessary for modifications needed to bring the Bilibino plant up to current Russian safety standards.

The team also advised establishing and implementing procedures to exchange data and information from time to time in the areas of health physics and safety, system design and operation, plant modifications, decontamination and materials performance, and maintenance procedures.

A list equipment and systems in which the Bilibino plant is interested was received by the team following the visit. It included:

- Miniature equipment on recycling or reducing solid, low-activity wastes
- Diagnostic equipment for monitoring materials performance
- Spectrometric and radiometric apparatus for control of environmental contamination
- Portable means of radio communications
- Facsimile and electronic mail equipment.

1996 U.S. Visit. Ten officials from the State of Alaska, the Department of Energy's Pacific Northwest National Laboratories (representing the International Nuclear Safety Program), and the U.S. Arctic Research Commission visited the Bilibino plant October 6-9, 1996.

The meeting's purposes were to:

- Explore possibilities for direct communications between the Bilibino plant and the State of Alaska.
- Understand the status of radiological monitoring and emergency preparedness at the plant. (This included investigating the possibility of establishing a real-time radiation monitoring network on and around the plant site.)
- Understand the plant's safety status.
- Determine areas for possible cooperation to improve safety at the plant within the scope of the International Nuclear Safety Program.

The plant director said the economic situation in Russia continues to slow progress toward needed safety improvements at Bilibino. He noted that a significant portion of the plant's costs are not being paid.

Protocol Signed. A protocol was signed as a result of the trip. It provides for improved communications, including emergency response notifications, and inclusion of the Bilibino plant in activities of the International Nuclear Safety Program.

The protocol also states that, according to the plant director, personnel turnover has increased, thereby reducing the level of staff experience and creating a shortage of fully qualified personnel. Training improvements were noted as a high priority.

Other top priorities identified included methods of improving maintenance of power plant equipment, and obtaining and installing additional safety equipment.

The plant is also planning a dry fuel storage project and is interested in cooperative efforts to ensure safety. The team reported overall waste management and monitoring activities at the plant appeared to be sufficient and did not pose significant risk to the public or environment.

KALININ NUCLEAR POWER PLANT

Type: VVER-1000

Units: Two (a third unit is under construction)

Total megawatts (net): 1,900 (950 per unit)

Location: Tver, Volga (Russian Federation)

Dates of initial operation: Unit 1 - June 1985
Unit 2 - March 1987

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Operating History

According to Kalinin management, some 40 improvements to safety and reliability have been made at the plant since it began operating, including the replacement of half-length control rods by full-length control rods and the modification of steam generator blowdown.

A team of experts from the International Atomic Energy Agency that visited the plant in July 1994 reported two operational events classified as Level 2 on the International Nuclear Event Scale (INES); both occurred in 1990.

The two units had an average availability factor of 68 percent for the first six months of 1994, and an average availability factor of 70 percent for the period 1989-1993.

In October 1996 Rosenergoatom reported that all operations unrelated to safety at the Kalinin plant stopped—reactor operation continued—when workers went on strike for back-pay. Workers had not been paid since July.

Technical/Upgrading Activities

A number of upgrades have occurred or are under way at Kalinin's nuclear units:

- Damaged thermal insulation on containment equipment was repaired to help prevent strainer clogging.
- A linear position indicator has been installed on the control rod.
- On-site emergency power supplies are being improved by introduction of a movable energy supply system.
- A water spray system is being installed in the machine hall.

Additional Plans

- Kalinin management has announced preparations for replacing the plant's steam generators and has expressed interest in obtaining a steam generator tube inspection/repair manipulator from the French company Framatome.
- Under a contract signed with Framatome in September 1991, Kalinin will receive a machine to remove bolts on steam generator manhole covers.
- The Russian government had planned to complete Kalinin's third unit—a VVER-1000—in 1996, but in early 1995 a Rosenergoatom official said that a lack of funds was preventing its completion. He added that Russia was trying to obtain $200 million in funding from several Italian banks and the U.S. company Westinghouse. Construction on a fourth unit at the site has been halted. Unit 3 could be operational in 1998, according to an official of the Ministry of Atomic Energy. Germany's Siemens is to supply some equipment for the unit, including electrical and instrumentation and control equipment, diagnostic systems, hydrogen removal systems and in-service inspection equipment.

International Exchange/Assistance

International activities involving the Kalinin plant have included:

U.S. Assistance. A U.S. team from the U.S./Soviet Joint Coordinating Committee on Civilian Nuclear Reactor Safety Working Group 9, which targets plant-diagnostic tools, has visited the plant.

In March 1992, Simulation, Systems and Services Technologies Co. (S3 Technologies) began work to support the development of a training simulator for the Kalinin site.

Whittaker Electronic Resources plans to install upgraded insulated cabling at Kalinin.

For details of U.S. assistance under the Department of Energy's International Nuclear Safety Program, see the section on **DOE Programs**.

European Union Assistance. The EU is engaged in an engineering assessment and design review of backfitting measures. An integrity assessment of VVER-1000 reactor pressure vessels, including embrittlement, is another ongoing effort. Safety valves on the steam generator of Unit 1 are being replaced.

Upgrading of emergency cooling system pumps is a planned project.

WANO Exchange Visits. Under the auspices of the World Association of Nuclear Operators, the staffs of the Kalinin plant and Pennsylvania Power & Light's Susquehanna nuclear power plant have visited each others' plant. In addition, Kalinin has hosted personnel from the following plant:

- United States' Shearon Harris plant (February 1993).

Personnel from Kalinin have visited the following plant:

- United States' Shearon Harris plant (March 1992, August 1994, October 1995).

Plant Twinning. The Kalinin plant is twinned with Germany's Brokdorf plant.

IAEA Training Seminar. An International Atomic Energy Agency training seminar was held at the Kalinin plant Feb. 15-17, 1994. The purpose of the seminar was to train operators and regulators in the use of the ASSET—Assessment of Safety Significant Events Team—methodology to identify safety issues, assess their consequences, and eliminate the root causes of likely future incidents and accidents. An IAEA seminar demonstrating the practical use of ASSET analysis procedures was scheduled to be held at the plant March 18-20, 1997.

Inspections

ASSET Mission. An ASSET mission from the IAEA visited the Kalinin plant July 4-15, 1994. The team reviewed 221 events that had occurred at the plant over the past 10 reactor years of operation. Of these events, 122 were relevant to safety and 11 exceeded the INES threshold—two were classified as Level 2 on the INES and nine were classified as Level 1.

The team was satisfied with the appropriateness of most of the corrective actions implemented by the plant, but identified pending safety problems in two areas—control of reactivity and cooling of fuel—attributed to five factors:

- reliability of instrumentation and control (I&C) equipment
- reliability of sealing of emergency core cooling system (ECCS) pumps
- quality verification of maintenance work
- reliability of operators' actions and
- control rod insertion time.

According to the team, these problems are related to a degradation of the plant's defense in depth, but have not resulted in any measurable on-site or off-site safety consequences to date. However, the problems have potential consequences for both plant safety and reliability. They have affected two performance indicators for reliability—unplanned shutdowns and plant availability factor. According to the ASSET mission, both of these indicators showed slight negative trends for 1993 and 1994.

The most important pending safety problem is that of control rod insertion time, which exceeds the limit prescribed in the technical specifications. Similar problems have been identified at other VVER-1000 plants. Kalinin has taken appropriate measures and long-term corrective actions are being determined at the national level. A second safety problem—reliability of sealing of ECCS pumps—will probably be eliminated soon, as new design seals have been satisfactorily tested and ordered for replacement.

The other three pending problems—reliability of I&C equipment, quality verification of maintenance work, and reliability of operators' actions—have been analyzed by plant management but are not yet under satisfactory control.

The team offered an action plan to enhance incident prevention. The plan included recommendations for systematic and independent verification of the quality of maintenance work, the extension of the plant surveillance program to include closer monitoring of the operability of I&C and electrical equipment, and the enhancement of the plant's feedback program.

The team recommended a follow-up ASSET mission in two years.

Planned ASSET Mission. An ASSET peer review mission to Kalinin was scheduled for September 1997, but has been rescheduled for July 8-14, 1998. The mission will review the plant's analysis—using ASSET methodology—of 12 events that reflect safety culture issues.

KOLA NUCLEAR POWER PLANT

Type: VVER-440 Model V230 (units 1 and 2)
VVER-440 Model V213 (units 3 and 4)

Units: Four

Total megawatts (net): 1,644 (411 per unit)

Location: Polarnyye Zori, Murmansk (Russian Federation)

Dates of initial operation: Unit 1 - December 1973
Unit 2 - February 1975
Unit 3 - December 1982
Unit 4 - December 1984

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Operating History

In September 1992, a break in a condensate water tank resulted in a small, contained water leak.

In November 1992, Unit 1 experienced an unplanned shutdown when a short circuit led to the loss of DC power supply. The unit's backup diesel generators then failed to start. The reactor remained under control throughout the incident, which was classified as Level 2 on the International Nuclear Event Scale (INES).

A tornado in February 1993 damaged transmission lines supporting the Kola plant and led to turbine and reactor shutdowns at all four operating units. The event was classified as Level 3 on the INES. Emergency diesel generators for units 2, 3 and 4 were successfully started up. The diesel generators for Unit 1, however, did not start as planned, and battery power kept the plant's instrumentation in operation. That event was classified as Level 2 on the INES.

In May 1993, pressure dropped in Kola 3's primary circuit after a safety valve was incorrectly opened. The pressure drop activated the unit's emergency safety system. The event was classified as Level 1 on the INES.

In March 1994, two leaks occurred at the plant; coolant leaked from Unit 2's auxiliary primary circuit cleanup system after a pipe rupture, and reactor coolant leaked from a flange in a control rod drive mechanism in Unit 3. Rosenergoatom, the Russian nuclear plant operating organization, initially classified the event at Kola 2 as Level 0 on the INES. But a special team from Russia's nuclear safety inspectorate—Gosatomnadzor—visiting the plant in mid-March to investigate the two events reportedly said the Kola 2 event was more serious, speculating that it might have been a Level 3. The final classification, reported in July, was Level 2. According to Russia's INES national officer, such an event would normally be classified as Level 1, but it was uprated to Level 2 because of safety-culture deficiencies.

In October 1994, Moscow radio reported that Kola was suffering from a shortage of spare parts and nuclear fuel, and as a result only one of the plant's four units was operating.

In September 1995, Kola plant operators cut off power to the nuclear submarine base of the Russian Northern Fleet because the base had not paid its electricity bills. Power was restored to the base after the Russian military sent armed soldiers to the plant. The loss of electricity reportedly left several decommissioned nuclear-powered submarines with no means of powering the reactors' cooling systems. As a result of this and other similar incidents at Russian military bases, Prime Minister Chernomyrdin signed an order in late September prohibiting regional power systems from cutting off electricity to military installations.

According to the Russian press, in early October 1995 the Kola regional electricity company was owed 27 billion rubles by the military. Another report cited the Kola plant's chief engineer as estimating 500 billion rubles was owed by the station's customers for electricity already supplied. The military and state-run factories are the main customers for Kola's electricity.

Technical/Upgrading Activities

Kola's nuclear units have undergone a number of upgrades:

- In 1989, the plant's fire-fighting water supply system was improved. Other fire-protection upgrades made in 1989 included painting cables with fire-retardant materials.

- Engineers modified the plant's boron-injection system and annealed the welds of a reactor vessel in 1989 to correct embrittlement problems.

- Fast-acting, automated valves have been installed to separate steamlines for the plant's steam generators.

- Dummy assemblies have been installed in pressure vessels of units 1 and 2 to reduce neutron flux on vessel walls.

- For units 3 and 4, installation of a venting system to the reactor vessel head and to other high elevation points of the primary circuit was completed.

- A new department was created in 1988 for personnel selection and training, and psychological and physical testing facilities were installed, along with a "basic principles" training simulator.

- Under a program implemented in 1987, plant operators spend 3½ weeks annually on team training, simulator work and psychological testing.

- Following the 1993 tornado-related incident, emergency diesel generators received larger fuel supplies and improved to assure restarts.

Additional Plans

Russian authorities have announced plans to build two or three new 640-megawatt VVER reactors with enhanced safety features at the Kola site. The first of the units is scheduled to begin operating in 2003.

Kola Units 1 and 2 were to be closed in 2003-2004 as the new units came on line. Questions of funding for the new units have led to speculation about upgrading units 1 and 2 to allow continued operation for up to 10 more years beyond the mandated closing dates.

International Exchange/Assistance

Scandinavian Support. In November 1992, satellite links between Kola and the Nordic countries were set up.

Norway announced in early 1993 that it was providing a grant of Kr 20 million ($2.6 million) for upgrading the Kola plant. The grant is intended for improvements in five areas of plant operations:

- emergency power supplies (diesel generators),
- international communications,
- fire protection for electrical and control panels,
- instrumentation renewal, and
- operator training in Norway.

However, Norway wants a liability agreement with Russia before it begins doing work at the Kola plant. It has asked the Russian government for a written statement granting indemnity in the event of an accident.

Finland announced in 1993 that it had earmarked FM 4 million ($720,040) to improve safety at the Kola plant. In January 1994, the Finnish Ministry of Trade and Industry and the Ministry of Foreign Affairs decided to finance the delivery to Kola of a simulator. The simulator is capable of handling plant design modifications and simulating various disturbances and accident situations. The Finns will train Kola operators in simulator operation. The two Finnish ministries also decided in June 1994 to finance a second project in which the simulator would be extended into a compact training simulator in 1995. The training simulator is expected to go on line in fall 1997.

With funding from the Finnish Ministry of Trade and Industry, IVO International is involved a backfitting program at Kola that includes—in addition to the provision of the simulator—design of complementary emergency feedwater systems, consultations on equipment qualification and on maintenance procedures, analysis of primary-to-secondary leaks and a boron dilution study.

Norway has undertaken instrumentation and control improvements at units 3 and 4 involving rotating machine monitoring and sensors for emergency conditions. It has also contributed to upgrading the chemistry laboratory.

German Assistance. Under a contract with Germany's Siemens AG, Kola will receive various plant systems, along with the technical expertise that will enable Russia to manufacture these systems themselves. Equipment already provided to units 1 and 2 includes monitoring systems for loose parts, noise and vibration. Delivery of the non-nuclear-related equipment began in 1993. The supply of equipment was reportedly financed through a barter arrangement. Siemens took a large consignment of nickel ore from a local Russian mine, which it then sold on world markets; as payment for the ore, the Russian mine received electricity from Kola.

In 1996, Siemens experts examined the integrity of welds on steam generator equipment at the plant, using a mast-manipulator provided by the company.

The German company Nukem has agreed to upgrade Kola's radioactive waste facilities. The two-year project, which will cost DM 7.5 million ($4.02 million), involves fitting the plant's existing radioactive waste incineration unit with a modern off-gas cleaning system and building a treatment unit for liquid radioactive waste. Nukem will also supply monitoring equipment to measure the residual fuel in used fuel assemblies.

European Union Assistance. The EU is involved with probabilistic safety analysis activities for Units 1 and 2, as well as investigation of and upgrades for reactor pressure vessel embrittlement concerns. It is engaged in engineering assessment and design review of backfitting measures at Units 3 and 4. A project to install a steam generator leak detection system at Units 3 and 4 is planned by the EU.

Under the TACIS program, Cassiopee (*Consortium d'Assistance Operationelle aux Pays de l'Europe de l'Est*) is developing an integrated management plan for a repository to be developed for waste from the Kola plant, research institutions, and nuclear-powered naval vessels. Cassiopee was formed in 1993 to help the countries of eastern Europe develop radioactive waste management systems. Member countries are Belgium, France, Germany, the Netherlands, Spain, and the United Kingdom.

U.S. Aid. Under the U.S. assistance program, a U.S. company—Promatec—has a contract to upgrade pressure and fire barriers in the confinement area of units 1 and 2. The project entails sealing cable penetrations and weld seams. Penetration sealing gear was sent to the plant in 1995.

WANO Exchange Visits. The World Association of Nuclear Operators has sponsored several exchange visits involving the Kola plant. The plant has hosted personnel from the following plants:

- Slovak Republic's Bohunice plant (June 1992),
- United Kingdom's Heysham plant (June 1992),
- Czech Republic's Dukovany plant (March 1996).

In addition, personnel from Kola have visited the following plants:

- United Kingdom's Heysham plant (January 1992, July 1994),
- United States' North Anna plant (November 1993, October/November 1995),
- United States' Byron plant (October 1994),
- United States' V.C. Summer plant (December 1996).

Plant Twinning. The Kola plant is twinned with Germany's Emsland plant, U.K.'s Heysham 1, and the North Anna plant in the United States. During exchange visits between Kola and Heysham, staff of the two plants have discussed such issues as quality assurance, reactor operations, mechanical maintenance and fuel-cycle management.

IAEA Training Seminars. An IAEA seminar demonstrating the practical use of ASSET analysis procedures for assessment by plant personnel of operational events was held at the plant April 23-25, 1996.

Inspections

ASSET Mission (Units 1 and 2). At the request of the former Soviet government, an International Atomic Energy Agency (IAEA) ASSET (Assessment of Safety Significant Events Team) mission visited Kola April 15-26, 1991. The purpose of the mission was to identify operational issues relevant to safety, rate their significance to safety on the basis of the International Nuclear Event Scale, select pending safety issues for root-cause analysis, and offer recommendations on enhancing incident prevention.

The team examined Kola's operating history and incident-prevention program. It said management was technically qualified and senior staff was knowledgeable. The team added that management was fully aware that Kola units 1 and 2, the V230s, did not comply with current safety standards. It said plant management recognized that staff had to be more vigilant for this reason, and was encouraging a safety-conscious attitude on the part of staff.

To improve its incident-prevention program, the team recommended that plant management coordinate three activities—quality control, preventive maintenance, and surveillance of plant operations to systematically remove any root causes of safety-relevant deviations.

Finally, the team suggested improvement in the plant's housekeeping standards and cleanliness.

Safety Review Mission (Units 1 and 2). An IAEA safety review mission visited the Kola plant Sept. 9-27, 1991, as part of IAEA's program on the safety of VVER-440 Model V230 reactors. The mission, composed of 15 international experts, carried out an in-depth review of 12 areas:

- management, organization and administration,
- training and qualification,
- operations,
- maintenance,
- fire protection,
- emergency planning,
- core design,
- system analysis,
- component integrity,
- instrumentation and control,
- electric power, and
- accident analysis.

Based on its review, the mission concluded that some of the design deficiencies of the V230s persisted in units 1 and 2, especially in the areas of instrumentation and control, and the physical separation of safety equipment.

The experts recommended that plant management focus on several areas of weakness in plant operation, including inadequate staffing of control rooms, inadequate normal and emergency operating procedures, failure to correct non-confirming conditions, and lack of a quality assurance program.

The experts also identified several design upgrades that needed to be made, including modifications to the service water system, analytical studies and evaluation of proposed leak detection system, development of a systematic, comprehensive and well-documented accident analysis, and the general reconstruction of the instrumentation and control system.

Follow-Up ASSET Mission (Units 1 and 2). An ASSET follow-up mission visited Kola Oct. 4-8, 1993, to assess improvements in incident prevention as a result of management's implementation of recommendations by the 1991 ASSET mission. The team evaluated plant responses to the 23 recommendations made by the first ASSET mission. It found that:

- In 11 cases, the recommendations had been carried out.

- In four cases, the recommendations had been partly carried out, but plant management was preparing a program to conclude the work.

- In six cases, the recommendations had been partly carried out.

- In one case, the recommendation had not been carried out, but some efforts to do so had been observed; the team agreed that in light of the analyses done by Kola specialists, implementing this recommendation—changing the system of labeling equipment—would be disadvantageous to the plant.

- In the case of one recommendation—improving management coordination—the plant has reached agreement with a consulting research institute in its effort to carry out the recommendation.

The team also identified safety problems in three areas: inadequate procedural guidance for plant personnel; quality of operational personnel; and potential for degradation of the safety-support-function power supply to safety equipment.

The team made the following recommendations:

- Operational personnel should be trained to improve their understanding of the priority of nuclear safety activities over protection of equipment.

- Instructions should be improved to identify safety-related activities.

- Surveillance of personnel proficiency in all emergency conditions should be improved.

- Plant management should establish a clear policy for carrying out personnel surveillance during design-basis emergency situations.

Planned ASSET Mission. An ASSET peer review mission to Kola was scheduled for Sept. 2-6, 1996. The mission was to review the plant's analysis—using ASSET methodology—of 12 events that reflect safety culture issues. At present, the mission has not been rescheduled.

Finnish-Led Mission. According to press reports, a Finnish-led mission visited the Kola plant in September 1996. The mission team—which included six Finns, one Swedish representative, and nine Russians—reviewed operational safety at the plant. Team findings were said to include high internal quality assurance, thorough reporting of safety problems, and good follow-up to ensure correction. The mission's top-ranking Finn reportedly said that all control instrumentation at units 1 and 2 had been replaced and the reactor protection system was totally refurbished.

KURSK NUCLEAR POWER PLANT

Type: RBMK-1000

Units: Four

Total megawatts (net): 3,700 (925 per unit)

Location: Kursk (Russian Federation)

Dates of initial operation: Unit 1 - October 1977
Unit 2 - August 1979
Unit 3 - March 1984
Unit 4 - February 1986

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Operating History

In January 1993, a pipe broke in Unit 3, dispersing a radioactive aerosol within the plant. The event was classified as Level 1 on the International Nuclear Event Scale (INES). Unit 2 was closed in March 1993 after a short circuit occurred during routine maintenance.

In November 1995, two employees at Unit 4 received radiation doses above the permitted annual limit when they were extracting a fuel assembly from a fuel channel after a plug in a fuel rod had ruptured. The incident was classified as Level 2 on the INES.

In 1991, Unit 1's lifetime average capacity factor was 72 percent, that of both Unit 2 and Unit 3 was 71 percent and Unit 4's was 78 percent. In March 1994, however, the plant was reportedly operating at only about 50-percent capacity because of a shortage of nuclear fuel.

Additional Plans

Upgrades similar to those completed on Leningrad Unit 1—the replacement of 1,600 pressure tubes—began on Kursk Unit 1 in 1993. Pressure tube replacement is complete at Unit 1 and has begun at Unit 2. Replacement is scheduled to start at Unit 3 in 1999 and at Unit 4 in 2002. Additional backfit plans include: seismic upgrades, improved fire protection, diagnostic systems, and instrumentation and control systems for units 1 and 2.

In May 1992, Minatom said that units 1 and 2 would probably be the first RBMKs in Russia to be decommissioned for safety reasons.

Kursk Unit 5—which was 60 percent complete at the time of the Chernobyl accident—missed its scheduled 1995 completion date because of a lack of funds. But in early 1997, a Minatom official said the government had provided construction funding and the unit could be completed in 1998.

International Exchange/Assistance

U.S. Aid. Under the U.S. International Nuclear Safety Program, the Kursk plant received worker protective clothing and ultrasonic inspection equipment (see **DOE Programs** for details).

Canadian Assistance. Canadian representatives are working extensively with the Kursk plant in several areas, including operational training and transfer of Canadian operating codes, fuel channel and flow meter sealing, spent-fuel burn-up determination, spent fuel handling and decommissioning.

European Union Assistance. An independent alternative shutdown system is being tested to improve redundancy and diversity.

A planned EU effort involves the modernization of the RBMK training center at Desnogorsk so the program may include additional disciplines.

Russian Technical Assistance. The Russian fuel manufacturer, Mashinostroitelniy Zavod Elektrostal, has modified the fuel for RBMK reactors to reduce the void coefficient and thus improve safe operation. In addition, stabilized power supply sources for control and protection systems are being introduced.

WANO Exchange Visits. The World Association of Nuclear Operators has sponsored several exchange visits involving Kursk. The plant has hosted personnel from the following plants:

- United States' Susquehanna plant (May 1991, July 1993, July 1994),
- United Kingdom's Dungeness B plant (July 1994).

In addition, personnel from Kursk have visited the following plants:

- United States' Susquehanna plant (August 1991, August 1994),
- France's St. Laurent plant (November 1992, May 1993),
- United States' Plant Hatch (October 1996).

Spent Fuel Facility. Rosenergoatom—the Russian nuclear operating organization—awarded a contract in 1994 to the French company SGN/Reseau Eurisys to build a spent fuel dry storage facility at Kursk. The facility will be capable of storing 8,000 metric tons of spent fuel. However, the contract was subsequently canceled.

In December 1995, the German company Gesellschaft für Nuklear-Behälter announced that it had signed a contract to build a radioactive waste storage facility at the plant and to supply up to 240 specially built containers. The first containers will be built in Germany, with manufacturing later transferred to Russia. The company will control production quality, train specialists and provide know-how for container production.

Plant Twinning. The Kursk plant is twinned with Germany's Mühlheim-Kärlich plant and the Susquehanna plant in the United States.

IAEA Training Seminar. Although the International Atomic Energy Agency is known for its inspection missions—including its Assessment of Safety Significant Events Team (ASSET) missions —to nuclear power plants, the agency also conducts ASSET training seminars at a country's request. The seminars are designed to train operators and regulators in the use of the ASSET methodology to identify safety issues, to assess their consequences, and to eliminate the root causes of likely future accidents and incidents.

An IAEA seminar demonstrating the practical use of ASSET analysis procedures for assessment by plant personnel of operational events was held at the plant April 4-6, 1995.

Inspections

ASSET Mission. In July 1992, the IAEA conducted its first ASSET mission to an RBMK at the Kursk plant. The purpose of the mission was to assess the plant's safety provisions for preventing incidents and accidents. Among the team's findings:

- The plant management is highly qualified, and the operating staff dedicated and knowledgeable.
- Of 153 safety-significant events over the plant's operating history, all but 21 were below the International Nuclear Event Scale, and those 21 were Level 1 events.
- About 25 percent of deficiencies were detected by routine surveillance, which left significant room for improvement.

The team recommended: a better system to prevent equipment failures, stronger assurance that safety systems receive power supply, improvements in maintenance procedures, and better testing procedures for the emergency core cooling system.

The team said a follow-up ASSET mission was advisable in two to three years.

ASSET Topical Analysis Mission. An ASSET topical analysis mission visited the Kursk plant Sept. 4-13, 1995. The mission was part of the program launched by Rosenergoatom to consolidate safety culture at Russian nuclear power plants.

The aim of the mission was to identify the root causes of safety culture issues that were the cause of events between July 1992 and July 1995. The ultimate objective was to contribute to safer electricity production through improved incident prevention.

The team found that the actions taken by the plant following the first ASSET visit in July 1992 had led to visible progress in incident prevention. However, the team noted that 77 safety-relevant events had occurred since then, demonstrating the existence of plant problems that were not being addressed by management in a timely manner to prevent failures during operation.

The team selected six events reflecting safety culture issues for in-depth root-cause analyses. The events were significant because of their potential impact on the safe production of electricity. Degradations of defense-in-depth resulting from safety culture issues have led either to undue activation of safety functions such as reactor shutdown or to situations where safety functions, fuel cooling and confinement were only adequate.

For most of the events analyzed, the team confirmed that appropriate corrective actions had been implemented to eliminate the identified weaknesses. The team, however, recommended that:

- Surveillance testing of operating and maintenance personnel proficiency with respect to vigilance, safety awareness and qualification for tasks should be developed to identify in a timely manner unforeseen degradations.

- Training programs should include safety awareness as the most important aspect to be developed among workers and supervisors.

- The effectiveness of the three feedback loops—to maintain effective defense-in-depth based on personnel proficiency, equipment operability, and procedure adequacy—should be assessed each year on the basis of plant safety performance.

The team concluded that safety culture at Kursk is developing at a reasonable pace, but noted that there is still room for improvement in specific areas as highlighted by the root cause analyses. The team suggested that the plant annually conduct its own analysis of performance using ASSET procedures, and produce its own ASSET reports for peer review every two to three years by an international ASSET team.

To date, no follow-up ASSET mission to the Kursk plant has been scheduled.

LENINGRAD NUCLEAR POWER PLANT (also known as Sosnovyy Bor)

Type: RBMK-1000

Units: Four

Total megawatts (net): 3,700 (925 per unit)

Location: Sosnovyy Bor (Russian Federation)

Dates of initial operation:
Unit 1 - November 1974
Unit 2 - February 1976
Unit 3 - June 1980
Unit 4 - August 1981

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Operating History

In March 1992, Unit 3 experienced a fuel channel rupture that was classified as a Level 2 incident on the International Nuclear Event Scale. A March 24 report by the Russian Ministry of Atomic Energy stated that the cause of the incident was a faulty valve. After undergoing maintenance, Unit 3 was shut down until June 1992, when it was brought back up to full power.

In September 1993, the Leningrad plant reportedly had only enough uranium fuel to operate for another three months. The plant had no money to buy fuel because it was owed 26 billion rubles by electricity users. In January 1994, the plant reportedly faced shutdown because of a lack of fuel. In August, the plant director reportedly said that the plant's bank account had been closed because the plant was unable to pay its taxes. In January 1995, the plant reportedly once again faced shutdown because of a lack of fuel. In September 1995, St. Petersburg television reported that the plant had reduced its power output because of fuel shortages.

In May 1995, a report was issued about a reactivity excursion and fuel failure at the plant's Unit 1. According to the Finnish Center for Radiation and Nuclear Safety, the report was a hoax. Unit 1 was shut down in November 1994 for backfitting, and was still shut down at the time of the report. The report was telexed to several foreign nuclear safety organizations by mistake when a plant resident inspector pushed the wrong button in trying to connect a new radiation monitoring system to the plant's satellite connection to the Finnish safety organization.

The Leningrad plant acquired the status of a separate operating utility in 1992, and reports to the Deputy Minister of Atomic Energy as an independent federal enterprise.

Protests Over Wage Arrears. In June 1996, the trade union leader of the Leningrad plant reportedly began a hunger strike to press demands for payment of back wages. Other plant personnel undertook a protest action, demanding the removal of the plant director.

A commission of the federal tax police service investigated and was said to have found flagrant violations in economic and financial activities at the plant. The protest action was suspended after several weeks, when criminal cases were initiated against the deputy in charge of capital construction at the plant and against the plant director. Plant operations reportedly continued as normal.

A small number of staffers of the Leningrad plant were reported to have started another hunger strike in November 1996, again protesting salary non-payments. Wage arrears amounted to 25 billion rubles. Several days later, more than 150 plant workers staged a "warning strike" and demanded resignation of the government, a trade union representative was quoted as saying.

After more than a week, with the plant on the verge of a shutdown from Gosatomnadzor, the protest action ended. Partial payment of back wages was made and additional payments were promised to be made by the end of December.

Plant employees participated in a protest march to Moscow in July 1997 by representatives of seven Russian nuclear power plants (see **Nuclear Energy in the Russian Federation**, page 101). The plant director said that in August, staff would begin receiving overdue wages for June and July.

In late July, the plant was forced to reduce capacity because of a shortage of fuel. The fuel production companies agreed to provide credit for the supply of enough fuel—scheduled to arrive in August—for two weeks of operation.

Technical/Upgrading Activities

The first phase of planned upgrades, which focused on Unit 1, was completed mid-1992. Among key upgrades:

- A modernized feedwater system,

- Replacement of 1,600 pressure tubes, and
- Restoration of graphite blocks in the core and the installation of a new instrumentation and control system.

Unit 1 was taken out of service again in October 1994 for additional improvements: modernization of its reactor control and protection systems, and installation of new equipment for its water-steam separators.

A second phase of upgrades—first for Unit 2 and then for Unit 3—began in 1992. These involve:

- Seismic and fire-protection improvements, and
- The installation of a new diagnostic system and instrument and control upgrades.

As part of this phase, Unit 2's pressure tubes were replaced. Work on Unit 2 was completed in December 1994. Unit 3 was shut down in July 1995 for replacement of its pressure tubes.

The repair work and outage for Unit 3 was expected to be completed during the first quarter of 1997. In April, however, the station director announced that the unit would not restart until mid-August. During control tests it was determined that welded joints of more than 1,200 pipes should be examined, and 200 channels changed. A technology developed at the Leningrad plant for "in-turn moving" of the reactor graphite columns will reportedly be used for the first time in this operation.

Maintenance on Leningrad's other units has been rescheduled to accommodate the prolonged shutdown of Unit 3. At present, Unit 4 is scheduled for an overhaul in October, following the restart of Unit 3.

International Exchange/Assistance

U.S. Aid. In the fall of 1991, the U.S. company General Physics International Engineering & Simulation was awarded a $13 million contract to design an RBMK simulator for the Leningrad station. The project was expected to take about 3½ years to complete. Plant operators began training on the new simulator in early 1996, while it was still located in St. Petersburg. The simulator was to be moved to the plant later in 1996. For details on the Department of Energy's International Nuclear Safety Program, see **DOE Programs**.

Scandinavian Assistance. Representatives from Finland's Center for Radiation and Nuclear Safety joined Russian specialists in August 1992 to check the plant's welding joints. Technicians found no defects.

Finnish and Swedish representatives reported in October 1992 that conditions at the Leningrad plant had been vastly improved. The representatives visited the plant and assessed its quality and safety using International Atomic Energy Agency (IAEA) methodology. The team found plant operation, maintenance and control well-organized and noted that it was being operated in strict compliance with Russian standards. The team noted that plant management had steadily improved plant safety over the past few years, despite adverse conditions in Russia.

In March 1993, Finland's Center for Radiation and Nuclear Safety announced that it had earmarked FM 3.9 million ($702,390) for safety-related improvements at the Leningrad plant. As part of this effort, Finnish fire-fighting experts visited the plant in June 1993 to present proposals on improving fire protection measures. In October, Finland delivered about $100,000 worth of fire-fighting equipment for two units at the plant. Finland's Ministry of Foreign Affairs approved a government grant of FM 1 million ($180,100) to pay for a radiophone system for the plant. The system can be used to support fire-fighting operations as well as in other emergency situations and for testing plant systems.

Other Finnish Assistance. Improvement of the integrity of pressure-retaining components is an ongoing project. Upgrades to the plant's environmental monitoring system are planned.

Canadian Assistance. Representatives from Canada are working extensively with the Leningrad plant in a variety of areas. These include operational training and transfer of Canadian operating codes, sealing of fuel channels and flow meters, determination of spent-fuel burn-up, dry storage and decommissioning.

Japanese Support. In July 1993, Russian and Japanese experts met to discuss the installation of a hybrid sound-pressure noise detection system on Unit 2. In November 1993, Japan agreed to install the system. The cooperative effort is part of the 960 million yen ($8.1 million) cooperative agreement signed between Japan and Russia in March 1991.

European Union Projects. British Nuclear Fuels plc (BNFL) and Germany's Nukem GmbH have won contracts worth about DM 4 million ($2.1 million) to manage a project to upgrade fire protection and instrumentation and control systems at the Leningrad plant.

An independent alternative shutdown system is being tested to improve redundancy and diversity.

A planned EU effort involves the modernization of the RBMK training center at Desnogorsk so the program may include additional disciplines.

EBRD NSA Grant. In June 1995, Russia agreed to accept grants totaling 76 million ECU ($80.5 million) from the European Bank for Reconstruction and Development's Nuclear Safety Account for upgrades at three plants: Leningrad, Novovoronezh and Kola. Of the total, 30.6 million ECU ($32.4 million) were earmarked for the Leningrad plant. Projects were expected to include inspection and monitoring, non-destructive examination, fire protection, and components for emergency core cooling system upgrades.

Other. The Swiss are carrying out an investigation of RBMK pressure tube failures, while Italian representatives are engaged in nuclear fuel and pressure tube upgrades for RBMKs.

Unit 2 PSA. Based on the work done for the Barselina project, Western experts talked with officials from Russia's Research and Development Institute of Power Engineering (RDIPE)—the design institute for RBMKs—and the Leningrad plant about carrying out a similar probabilistic safety analysis at the Russian plant. Work began on the project in September 1996 after more than two years of negotiations between representatives of the U.K.'s AEA Technology, the U.S. Department of Energy and the Swedish International Project and plant management and RDIPE.

Data collection for a level 1 PSA began in March 1997, and the $4-million PSA project—which is being directed by Sweden's ES Konsult—is expected to be completed in September 1998. The results of the PSA will be reviewed by an independent, multinational group led by personnel from the Finnish Center for Radiation & Nuclear Safety, with representatives from Germany, Russia and Lithuania.

Russian Technical Assistance. The Russian fuel manufacturer, Mashinostroitelniy Zavod Elektrostal, has modified the fuel for RBMK reactors to reduce the void coefficient and thus improve safe operation. A pilot batch of the new fuel was scheduled to be loaded in Leningrad's reactors in December 1995. The results of the test will be analyzed in 1997.

WANO Exchange Visits. The World Association of Nuclear Operators has sponsored several exchange visits involving Leningrad. The plant has hosted personnel from the following plants:

- United Kingdom's Heysham 2 (September 1992),
- United States' Zion plant (September/October 1994).

The Leningrad plant also hosted a visit from personnel of the U.S. utility Commonwealth Edison in August 1995.

In addition, personnel from Leningrad have visited the following plants:

- United Kingdom's Heysham 2 (September 1993),
- United States' Zion plant (April/May 1994, June 1995, July 1995),
- United States' Plant Hatch (October 1996).

Plant Twinning. The Leningrad plant is twinned with Germany's Isar 1 and Britain's Heysham 2.

Inspections

ASSET Mission. An ASSET mission from the IAEA visited the Leningrad plant May 17-28, 1993. The team reviewed 327 operational events that occurred between January 1982 and April 1993, of which 152 were determined to be safety relevant. Of these, 144 were classified as Level 0 on the International Nuclear Event Scale (INES), seven were classified as Level 1 and one was classified as Level 2. The team felt it was significant that nearly 40 percent of the events had occurred at Unit 1. As a result of its analysis, the team identified five categories of recurrent events: short circuits, human failures, failures in electronic systems, bearing problems, and refueling problems.

The team also identified five safety problems that were undermining the plant's safety performance:

- Compartmentalized plant organization, with complex interface problems.
- No obvious regular and systematic reappraisal of the safety case to identify challenges to or inadequacies of the original safety acceptance criteria.
- Lack of safety culture.
- Lack of an effective surveillance scheme to identify potential weaknesses and possible initiators of events.
- Lack of detailed operating procedures.

The team concluded that the plant has the basic ingredients of a policy to improve safe and reliable operation, and it was satisfied with the appropriateness of most corrective actions implemented as a result of the lessons learned from the operational events. But it identified pending safety problems in the areas of reliability of equipment, personnel and procedures.

The team developed an action plan with recommendations for optimizing the balance between software and hardware safety provisions, for improving the plant program to prevent latent weaknesses, for improving feedback from operating experience, and for improving the quality of documentation. The team recommended a follow-up mission in two to three years to assess the progress made by the plant.

Follow-Up ASSET Mission. A follow-up ASSET mission visited Leningrad June 3-7, 1996, at the request of the Leningrad operating organization. The ASSET team consisted of seven experts selected from regulatory and operating organizations in Bulgaria, Finland, Japan, South Africa, Sweden, Ukraine, and Great Britain, supported by three IAEA professionals.

The review team noted an extensive program of modification during the previous three years led to the four units being available for electricity production about 70 percent of the time. It also said safety performance improvements were significant. The positive trends came about because of the stability of plant management, its commitment to safe operation and continuous efforts in developing plant capabilities to identify safety problems, evaluate their importance and learn lessons.

The objective of the plant self assessment was to answer seven basic questions:

- What are the pending safety culture problems?
- What is their significance to safety? (severity of the problems)
- Why did they happen? (direct causes)

- Why were they not prevented? (root causes)
- How to eliminate the pending safety culture problems? (repairs)
- How to prevent recurrence of the pending safety culture problems? (remedies)
- What are the corrective actions to be implemented? (action plan)

The self assessment carried out thoroughly addressed the basic questions and so provided a sound basis for strengthening efforts to prevent future operational failures, the team said.

Additionally, plant defense-in-depth measures taken in the hardware and software areas seemed to meet the intent of incident and accident prevention. But, the team concluded a number of minor degradations in defense-in-depth occurred because of ineffective quality control before operation and surveillance testing during operation. And feedback from degradations that were identified did not always prevent recurrence.

Still, plant safety culture is moving in the proper direction and the plant's own safety assessment indicates additional progress can be made in improving its ability to identify safety issues and learn lessons.

Several suggestions were made by the team to complement the plant action plan in the following areas: internal reporting events, commitment to event reporting, review of surveillance policy, procedure for document control, procedure for assessment of safety significance, system for prioritization of corrective actions, tracking of recurrence of events, staff awareness of events, targeting of effectiveness of routine surveillance, and promoting the systematic event analysis process.

Finally, the team made a strong recommendation to plant management that it require each unit manager to perform an annual self assessment of safety performance for review on site by the safety inspection department. The objective should be to obtain the approval of the plant director on each unit's specific annual action plan.

The team recommended that another ASSET mission be scheduled in two to three years to peer review the annual self assessment of each unit.

July 1997

NOVOVORONEZH NUCLEAR POWER PLANT

Type: VVER-440 Model V230 (two)
VVER-1000 (one)

Units: Three operating (two early-model VVERs—units 1 and 2—shut down in 1984 and 1990)

Total megawatts (net): 1,720 (two units at 385 each; one unit at 950)

Location: Voronezh (Russian Federation)

Dates of initial operation: Unit 3 - June 1972
Unit 4 - March 1973
Unit 5 - February 1981

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Technical/Upgrading Activities

Upgrades and remedial actions include:

- Corrective actions at units 3 and 4 (dummy fuel assemblies have been installed to reduce neutron flux) because of reactor-vessel embrittlement problems,
- 1979 repairs to shut-off valves in the primary loops of units 3 and 4 after faults were detected in welds,
- Painting of cables with fire-retardant material, and
- An automated radiation monitoring system has been introduced.

At unit 5,

- A separate pipeline to provide emergency water supply to the steam generator is being installed.
- The control rod system now has a linear position indicator, and

- A new water chemistry purification system is under construction.

Additional Plans

Before the break-up of the Soviet Union, planned upgrades for units 3 and 4 included:

- Installation of new fast-operating valves (since completed),
- A new acoustic diagnostics system,
- Replacement of emergency boron-injection pumps,
- Additional training to help operators deal with severe accidents,
- Upgraded operating procedures, and
- Expansion of in-service inspection programs.

In 1994, Russia's Department of Environment approved an environmental assessment needed for the construction of two new units at the Novovoronezh site. Units 6 and 7—1,000-megawatt reactors with passive safety features—are scheduled to come on line between 2002 and 2005, according to a protocol signed by Russia's Minister of Atomic Energy and the head of the regional nuclear administration. An application for authorization of the project from nuclear regulator Gosatomnadzor (GAN) is being prepared, and work is expected to begin by 2000.

International Exchange/Assistance

U.S. Assistance. Under the U.S. government's assistance program, a working group spearheaded by the Department of Energy—with the Institute of Nuclear Power Operations playing a key role—has been assessing the condition of the two VVER-440 Model V230 units at Novovoronezh. The group's goal is to determine what upgrades are needed at other VVER-440 Model V230 units. Three "expert groups" are focusing specifically on procedures, training and management controls. When implemented, the recommended changes are expected to be applied at all VVER-440 Model V230 plants in the region and, ultimately, to all VVER-440 Model V213s and VVER-1000s. See **DOE Programs**.

A U.S. team observed the annealing process conducted on the reactor vessel of Novovoronezh 3 as part of a working group on the subject, sponsored by the U.S. Nuclear Regulatory Commission (NRC). (Annealing is a heat-treatment process that can extend the life of the reactor vessel.) The NRC working group concluded that Russian engineers used reliable equipment and exercised considerable technical expertise. See **NRC Programs**.

German Contract. Under a contract with Germany's Siemens, Novovoronezh will receive various plant systems, along with the technical expertise that will enable Russia to manufacture these systems. Equipment already provided to units 3 and 4 includes loose parts, noise and vibration monitoring systems.

TACIS Project. Siemens and Electricité de France have a contract, funded by the European Union's TACIS program, to provide operator training at Novovoronezh.

Other EU Assistance. At units 3 and 4, operational and surveillance procedures, quality assurance programs, and fire protection equipment are all in the process of receiving upgrades. A planned project involves tightening leak confinement.

At Unit 5, pilot valves for the steam generator are being replaced. A severe accident analysis is being conducted.

Swiss representatives are helping to complete a probabilistic safety assessment for Unit 5.

WANO Exchange Visits. The World Association of Nuclear Operators has sponsored several exchange visits involving Novovoronezh. The plant has hosted personnel from the following plants:

- United States' Indian Point 2 and 3 (September 1992),
- Japan's Onagawa plant (September 1994),
- United States' Vermont Yankee plant (June/July 1995).

In addition, personnel from Novovoronezh have visited the following plants:

- United States' Indian Point 2 and 3 (November 1992),
- United States' Vermont Yankee plant (October 1994).

Plant Twinning. The Novovoronezh plant is twinned with France's Penly plant, with Germany's Gundremmingen plant, and with the Diablo Canyon and Vermont Yankee plants in the United States.

IAEA Training Seminar. Although the International Atomic Energy Agency is known for its inspection missions—including its Assessment of Safety Significant Events Team (ASSET) missions —to nuclear power plants, the agency also conducts ASSET training seminars at a country's request. The seminars are designed to train operators and regulators in the use of the ASSET methodology to identify safety issues, to assess their consequences, and to eliminate the root causes of likely future accidents and incidents.

Inspections

ASSET Mission (Units 3 and 4). At the request of the former Soviet government, an IAEA ASSET mission visited Novovoronezh May 13-24, 1991. The purpose of the mission was to identify operational issues relevant to safety, rate their significance to safety on the basis of the International Nuclear Event Scale, select pending safety issues for root-cause analysis, and offer recommendations on enhancing incident prevention.

Among the team's findings:

- Industrial culture at the plant "compares favourably with similar units already visited by the ASSET service."

- "Safety culture was found generally satisfactory."

- Management's attitude toward improvements and operational safety was found to be "very open-minded and responsible."

- The average capacity factor for each of the VVER-440 Model V230 units is above the world average for pressurized-water plants.

- Over the past 10 years, four events considered "safety significant" occurred at units 3 and 4, in addition to seven events considered "safety relevant." According to the IAEA, programs to identify precursors to these events were not adequate.

- Implementation of new measures in the management of preventive maintenance programs, root-cause analysis and other areas would help avoid safety violations in the future.

On the basis of its review, the team selected three safety issues for in-depth root-cause analysis: insufficient work coordination and control, insufficient procedural guidance, and insufficient reliability of a safety support function.

Safety Review Mission (Units 3 and 4). An IAEA safety review mission visited the Novovoronezh plant Aug. 12-31, 1991, as part of IAEA's program on the safety of VVER-440 Model V230 reactors. The mission, composed of 15 international experts, carried out an in-depth review of 12 areas:

- management, organization and administration,
- training and qualification,
- operations,
- maintenance,
- fire protection,
- emergency planning,
- core design,
- system analysis,
- component integrity,
- instrumentation and control,
- electric power, and
- accident analysis.

The objective of the mission was to assess the design and operational safety aspects of the units, taking into consideration plant-specific conditions such as improvements. The team identified a number of significant areas where operational safety should be improved. The major issues included: replacement of the plant's analog VVER-440 simulator with a modern simulator; improvement of the operator training program; improvement of normal and emergency operating procedures; and achievement of a consistent standard of maintenance and housekeeping work.

The team also identified some design weaknesses that warranted special attention, including the confinement, whose behavior under accident conditions should be analyzed, and the engineered safety features, whose deficiencies required more attention to realistic safety analyses.

Follow-Up Safety Review Mission (Units 3 and 4). A consultative mission visited the plant June 28-July 3, 1993, to give advice on the actions taken in response to the IAEA's technical report on the safety of VVER-440 V230 plants as well as the 1991 Safety Review Mission's report in the context of Russia's backfitting concept for the plant.

According to the team, the plant had made satisfactory progress or completed action on the 1991 mission's recommendations. In the design area, 40 percent of the issues identified in 1991 had been partly or fully addressed. All issues were expected to have been fully addressed by 1996.

The team noted that extensive inspections of all safety-relevant components had been made, but that the integrity of the reactor pressure vessel needed special attention as a future critical issue. The team noted that short-term or compensatory measures planned for the plant's mechanical, electrical, and instrumentation and control systems should be implemented as soon as possible, especially those that increase redundancy and protection against common-cause failures of the safety systems that cool the core. The team identified several long-term measures of high safety significance, including replacement of pressurizer safety valves, installation of main steam line fast isolation valves, and installation of a new emergency power supply system.

The team noted that about 80 percent of the operational safety issues had either been resolved or were progressing satisfactorily toward resolution. It recommended a review of operating procedures at the plant to ensure that changes resulting from backfit modifications are included in the procedures. Other recommendations included: evaluation of the proposal for a full-scope simulator to determine the need for additional technical and financial assistance, and completion of upgrading of emergency-response facilities.

Follow-Up ASSET Mission (Units 3 and 4). A follow-up ASSET mission visited Novovoronezh Nov. 29-Dec. 3, 1993. The team found that considerable progress had been made in implementing the recommendations of the 1991 ASSET mission. For example, said the team, an increased proportion of events had been found by surveillance (25 percent as opposed to 4.5 percent in 1991).

The team identified three safety problems that were still pending:

- Failures of safety-related equipment owing to problems with unreliable electrical components,
- Insufficient assessment of equipment conformance to working conditions (quality assurance), and
- Potential degradation of equipment operability owing to aging or insufficient maintenance.

The team recommended an action plan to address these problems, which included the replacement of component electrical insulation, vigorous pursuit of a proposed restructuring entailing the introduction of a quality assurance facility, and reviewing criteria for safety equipment classification and arrangements for its periodic inspection.

Technical Exchange Mission. At the invitation of the Russian government, Rosenergoatom and the Novovoronezh plant, an IAEA technical exchange mission visited the plant Nov. 27-30, 1995, in the context of the IAEA's program on the safety of VVER-440 Model V230 plants. The aim of the program is to provide both a safety evaluation and advice on measures to improve nuclear plant safety.

The purpose of the mission was to update the information available to the IAEA on the status of the plant's implementation of safety improvements, and to comment on the actions taken—with respect to both operational and design issues—in response to the IAEA's report on Model V230 plant safety.

Safety Review Mission. An IAEA safety review mission March 17-21, 1997, visited Novovoronezh unit 5—the first VVER-1000 unit to operate. The objective of the visit was to identify safety issues associated with the design and operational features of this model, and to compile information on the scope and status of implementation of safety upgrades. A previous assessment of the plant identified a number of deviations of the original design from current Russian standards. A large number of safety upgrades have been carried out, are being implemented or are planned.

The IAEA team identified 75 design safety issues, of which six are specific to Unit 5 and all the others are common to other VVER-1000 units. Safety issues specific to Unit 5 are lack of redundancy in the reactor protection system, lack of functional and physical separation of the emergency core cooling system, vulnerability of the feedwater system, insufficient capability of the boron injection system, and mechanical and electrical components and instrumentation and control equipment that are not designed and qualified for seismic conditions.

Planned ASSET Mission. An ASSET peer review mission to Novovoronezh scheduled for November 1996 has been rescheduled for June 10-18, 1998. The mission will review the plant's analysis of 12 events that reflect safety culture issues.

SMOLENSK NUCLEAR POWER PLANT

Type: RBMK-1000

Units: Three

Total megawatts (net): 2,775 (925 per unit)

Location: Desnogorsk, Smolensk (Russian Federation)

Dates of initial operation:
Unit 1 - September 1983
Unit 2 - July 1985
Unit 3 - October 1990

Principal Strengths and Deficiencies

For an overview of the principal strengths and deficiencies of Soviet-designed plants, see **Soviet Nuclear Power Plant Designs**.

Operating History

In February 1994, a transformer caught fire outside the plant complex. The fire was extinguished within 30 minutes, and the plant did not shut down.

Between 1983 and 1993, the plant's availability factor averaged 76 percent. But financial difficulties have reduced output at the plant. In August 1994, some 350 of the plant's employees refused to leave the plant in protest over a four-month delay in payment of salaries. In September, the plant reportedly had only one unit on line. The other two units were down for maintenance and awaiting spare parts. Cash shortages were said to be delaying the units' return to service.

According to a Russian news agency report in late January 1995, the Smolensk plant was operating at about 50-percent capacity, and had enough fuel for only another 10 days of operation.

In October 1996 Rosenergoatom reported that all operations unrelated to safety at the Smolensk plant stopped—reactor operation continued—when workers went on strike for back-pay. Workers had not been paid since June.

Faults in the control system of Smolensk unit 1 reportedly forced a shutdown of the unit in December 1996. A representative of Rosenergoatom said there was no emergency, no radioactive release, and faults were being eliminated.

A threatened March 1997 strike by contract workers who perform repair work at the Smolensk plant was not expected to affect plant operations, since it did not involve plant employees. But reports of a strike for back pay by engineering personnel in June 1997 contained no such claims.

The summer of 1997 saw employees of the Smolensk plant undertaking a 250-mile march to Moscow to demand back pay. Along the route, they were reportedly joined by colleagues from the Kalinin, Kursk and Novovoronezh nuclear plants. In addition, employees of the Leningrad plant reportedly started on a march to Moscow to meet their Smolensk colleagues.

At a meeting in Moscow with Deputy Prime Minister Vladimir Bulgak on July 16, representatives of seven nuclear power plants—including Smolensk—signed a protocol on the allocation of money to pay plant workers. According to the protocol, 123 billion rubles will be allocated each month—starting in July—to pay nuclear plant employees. In the fourth quarter of 1997, this amount will be increased to 300 billion rubles.

The office of First Deputy Premier Andrey Pershin said that back wages for the Smolensk staff would be paid beginning July 22. And according to the plant's director, 27 billion rubles had been transferred to pay for April and May wages.

Technical/Upgrading Activities

Safety Analysis Report. As part of the International Atomic Energy Agency's (IAEA) program on the safety of RBMK reactors, a safety analysis report of Smolensk's Unit 3 was used as the basic document for an IAEA review of the program in June 1993. Smolensk 3—a second-generation RBMK design—is one of two reference units for the program. The other is Lithuania's Ignalina 2.

At the meeting, held at the Smolensk plant, 100 experts from the West, IAEA and the former Soviet Union discussed concerns raised at a review meeting a year earlier at IAEA headquarters in Vienna.

Three issues from the Vienna meeting were discussed in detail: core monitoring and control, component integrity, and accident mitigation. Discussed in less detail were: support and safety systems, instrumentation and control, seismic safety, fire protection, and operational safety.

The reviewers made a number of recommendations with respect to design solutions and proposed improvements to Smolensk 3, including:

- The feasibility of installing an additional reactor-shutdown system should be considered.
- Further validation of accident-analysis results should be carried out, considering in particular the adequacy of the computer codes used.
- Separation of plant protection and control functions should be considered a priority.

- An analysis should be undertaken aimed at reducing the number of valves in the primary circuit without affecting the functions of the circuit or making maintenance more difficult.

- Fire protection should be improved.

The experts also made a number of observations, including:

- The unit's safety systems have a good level of redundancy.

- No major seismic problems have been identified with structures or equipment.

- Reactor operators are skilled and experienced, but heavy demands are placed on them by the frequent manual adjustments required to control power levels and channel flow.

- Many of the elements necessary for safe operation and good performance are in place, but many safety practices are dictated by rules from external organizations, which may result in a passive and unquestioning attitude toward safety.

Among the Russian upgrades that have occurred or are under way at Smolensk's nuclear units are:

- Cable rooms are being fitted with automatic fire-extinguishing systems.

- Roof panels in the machine hall are being replaced with nonflammable panels.

- Stabilized power supply sources for control and protection systems are being introduced.

- Unauthorized deactivation of reactor emergency protections has been prevented.

Major Upgrades. Work began on fire prevention, replacing old equipment, increasing the capacity of steam and gas dump systems, and extending the diagnostic capabilities on circulation system components at units 1 and 2 in 1996. Pressure tube replacement is scheduled to begin at Unit 1 in 1998 and at Unit 2 in 1999.

International Exchange/Assistance

WANO Exchange Visits. The World Association of Nuclear Operators has sponsored several exchange visits involving the Smolensk plant. The plant has hosted personnel from the following plants:

- United Kingdom's Torness plant (April 1992, September 1992),
- United States' Plant Hatch (August 1992),
- Japan's Shimane plant (August 1994).

In addition, personnel from Smolensk have visited the following plants:

- United Kingdom's Torness plant (March 1992, August 1992),
- United States' Plant Hatch (September 1992, January/February 1994, March 1996, October 1996).

TACIS Aid. Under the European Union's TACIS—technical assistance program to CIS countries—Scottish Nuclear was awarded a contract in 1993 to plan the installation of a system for controlling and scheduling maintenance activities at the Smolensk plant. Scottish Nuclear's Torness plant was twinned with Smolensk in 1991. Operation of the maintenance system software, called DESNA, at the Smolensk plant was described in published reports in fall 1996.

Other EU Assistance. An independent alternative shutdown system is being tested to improve redundancy and diversity.

A planned EU effort involves the modernization of the RBMK training center at Desnogorsk so the program may include additional disciplines. Also, protection of the cable network at Smolensk from potential fire damage is to be upgraded.

Plant Twinning. The Smolensk plant is twinned with Germany's Unterweser plant and the U.K.'s Torness plant.

U.S. Assistance. As part of the U.S. government's assistance program, experts completed a fire-hazards walkdown of Smolensk to determine what kind of remedial equipment would be required. Under the program, the plant is receiving such equipment as sprinkler heads, control panels, self-contained breathing apparatus and sealants.

Simulation, Systems, and Services Technologies Co. (S3 Technologies) received approval by the U.S. Department of Energy to support the construction of a control room simulator for Smolensk.

For details of DOE's International Nuclear Safety Program, see **DOE Programs**.

Canadian Assistance. Representatives from Canada are working extensively with the Smolensk plant in several areas. These include operational training and transfer of Canadian operating codes, sealing of fuel channels and flow meters, determination of spent-fuel burn-up, dry spent fuel storage and decommissioning.

Russian Technical Assistance. The Russian fuel manufacturer, Mashinostroitelniy Zavod Elektrostal, has modified the fuel for RBMK reactors to reduce the void coefficient and thus improve safe operation.

Spent Fuel Facility. Rosenergoatom—the Russian nuclear operating organization—awarded a contract in 1994 to the French company SGN/Reseau Eurisys to build a spent fuel dry storage facility at Smolensk. The facility would be capable of storing 5,000 metric tons of spent fuel. The first stage of facility was to have been operational in June 1995, but according to a Russian news agency report, construction was repeatedly delayed because of Russia's failure to maintain payment. The same report noted that the plant's existing spent fuel storage area was more than 90 percent full in June 1995. The contract has now been canceled.

A new Russian-built, pool-type storage facility began operation at Desnogorsk in February 1996, relieving the Smolensk plant's immediate fuel storage problems. The facility has a storage capacity of 13,500 spent fuel rods and is projected to operate for 40 years.

Inspections

ASSET Mission. An IAEA ASSET mission visited the Smolensk plant July 19-30, 1993. The team reviewed 316 events that had occurred between September 1983 and May 1993. Of these, the team considered 168 to be safety-relevant events; 16 of them were classified as Level 1 on the International Nuclear Event Scale, two were classified as Level 2 and the rest were Level 0.

After analyzing the events, the team identified 12 areas of recurring faults:

- 6 kV electrical system overvoltage,
- electrical cabling insulation degradation,
- instrumentation and control relay failures,
- fuel handling,
- electrical rectifiers and inverters,
- pipework weld integrity on safety-related systems,
- control rod and protection system,
- operator errors during testing,
- operator errors during plant transients,
- maintenance errors,
- lack of operational procedures, and
- inadequate maintenance procedures.

From these recurring faults, the team then identified seven significant problems impinging on safety. In all cases, appropriate corrective action had been taken, but only two were considered resolved. In the case of three recurring fault areas, the team commented on plant corrective actions:

6 kV system—redesign of the protection system has addressed voltage surges, and consequent cable damage is being addressed.

Control rod and protection system—many of the problems in this system have been addressed by installing correct capacity contractors on the 48V system.

Inadequate maintenance procedures—implementation of a schedule for routine maintenance and testing has improved the identification of problems before they occur in operation, but limitations in maintenance history and operational experience feedback result in too many instances of failure to operate as expected.

The team identified two problems—lack of quality in maintenance work and operator errors during testing—as being of significant outstanding concern.

The team noted that plant management was dedicated to the prevention of plant disturbances. In addition, the systematic surveillance program set up by management was helping to detect latent weaknesses. But further improvement is needed, and the team offered a number of suggestions and recommendations in this respect. Among them:

- Plant management should consider enhancing the “usability” of procedures by ensuring the participation of both operations and maintenance staff in their preparation.

- Plant management should extend the requirement for systematic requalification testing to all maintenance work.

- Plant management should extend the use of formal root-cause analysis to the investigation of all safety-relevant deviations.

Follow-up ASSET Mission. A follow-up ASSET peer review mission visited Smolensk Feb. 19-25, 1997. The mission reviewed the plant’s self assessment of safety culture on the basis of operational events that occurred at the plant between July 1993 and July 1996. It found that the plant had maintained a good operating record while undertaking a large safety-significant backfit program. “The positive trend in the area of prevention of incidents demonstrates clearly the efforts made since 1993 to enhance operational safety,” said the team.

The team found that a few safety problems had not been completely eliminated. These were in the areas of quality of maintenance work; operators’ actions in the control room and on the refueling machine; and the reliability of primary coolant pipework, diesel generators, inverted convertors and spray cooling pumps. These problems have the potential to affect the availability of safety functions.

The safety problems were mainly due to a number of weaknesses that were either not fully identified before operation or not addressed by the preventive maintenance program, the team said.

The team found that the action plan prepared by the plant addresses the pending safety problems identified and includes appropriate corrective actions. Plant management is committed to the completion and continuing review of the prioritization of these tasks. Where some of the corrective actions need time for implementation, interim actions have been implemented to enhance the prevention of operational failures.

The team concluded the Smolensk self assessment thoroughly answered seven basic questions:

- Plant defense-in-depth provisions made by plant management in hardware areas appear to have complied with the primary intent—the prevent of incidents and accidents.

- The events that occurred over the three-year period highlighted the vulnerability of plant provisions in the areas of qualification of maintenance personnel and vigilance of operating personnel.

- Systematic root cause analysis of the degradations identified as a result of operational failures or surveillance testing could have led to more comprehensive measures to prevent recurrence of similar failures.

- The plant's self assessment provides evidence of progress made in the plant capability to identify its safety issues, to asses their importance and to learn the lessons.

The team highlighted some additional lessons that can be learned from the pending safety problems and offered recommendations to complement the plant's action plan in the areas of safety qualification of specific procedures (maintenance) and specific category of maintenance personnel (electrical, instrumentation and control) and in the area of safety culture for timely identification of the problems (comprehensive testing) and prompt elimination of the problems (systematic analysis of the causes of any failure and implementation of corrective actions).

The team encouraged the plant's technical director to require plant staff to carry out an annual self assessment of operational safety performance, which should be reviewed at the plant site or at company level by an independent group. These regular assessments would support the identification of common issues and permit management to set priorities for safer and reliable electricity production.

Finally, the team suggested that an ASSET mission be scheduled sometime in the future to peer review the current annual self assessments of the plant's safety performance.