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NUCLEAR SAFETY

International Assistance Efforts to Make Soviet-Designed Reactors Safer

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The Honorable Joseph I. Lieberman
Chairman
The Honorable Alan K. Simpson
Ranking Minority Member
Subcommittee on Clean Air and
Nuclear Regulation
Committee on Environment and Public Works
United States Senate

The United States and other countries have serious concerns about the safety of 58 Soviet-designed civil nuclear power reactors located in the former Soviet Union and in countries in central and eastern Europe. These reactors do not meet international nuclear safety standards. Twenty-five of these reactors, because they are of the oldest design, pose the highest safety risk. Yet they continue to operate. Fifteen of these reactors are the type that exploded at Chernobyl, Ukraine, in 1986.

In July 1992, the Group of 7 (G-7)[1]—the major industrialized nations—announced a multi-million-dollar plan to improve the safety of these nuclear power reactors. To determine what progress has been made in implementing this plan, you asked that we provide you with information on U.S. and international assistance efforts aimed at improving the safety of these reactors. Specifically, this report describes (1) the goals and scope of the international assistance, (2) the United States' planned and ongoing assistance efforts, (3) the impact of the assistance provided, and (4) the potential for closing the highest-risk reactors.

Results in Brief

As of May 1994, about $785 million had been pledged to implement the G-7 assistance plan, primarily for improving the safety of the Soviet-designed civil nuclear power reactors located in the former Soviet Union and in central and eastern Europe. A longer-term goal of the assistance program is to shut down the most dangerous nuclear power reactors and replace them with alternative energy sources. The plan also calls for improving nuclear regulatory agencies in those countries operating Soviet-designed reactors. As of May 1994, only about 7 percent of the projects, worth about $57 million, had been completed.

[1]The seven countries are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

Under the international assistance umbrella, the United States has proposed safety projects valued at about $150 million, targeting approximately $85 million to Russia, $50 million to Ukraine, and $16 million to countries in central and eastern Europe. As of March 1994, the United States had spent about $18 million on safety projects such as providing training for reactor operators and nuclear regulators, fire safety equipment, and computer equipment.

It is difficult to determine whether the international assistance provided to date has made the reactors safer. The projects—mainly safety assessments and training—do not lend themselves to clear, measurable results. In addition, an absence of reliable data on the Soviet equipment makes quantifiable before-and-after comparisons difficult. Furthermore, some nuclear safety projects have been delayed because U.S. and European contractors are unwilling to undertake work without protection from liability in the event of a nuclear accident.

There are no guarantees that the international assistance effort will result in safer reactors or expedite the closure of the riskiest reactors. In fact, in the absence of a commitment to close down the reactors, the assistance may encourage their continued operation. Donor countries face formidable challenges in promoting the closure of the Soviet-designed reactors because the countries operating them depend on nuclear power to meet their needs for domestic energy and export income. However, the United States has agreed with Russia and Ukraine to study alternative energy options that include phasing out the riskiest reactors.

Background

The 58 Soviet-designed reactors pose significant safety risks because of deficiencies in their design and in their operation by plant managers and personnel who lack adequate training in many of the safety procedures practiced by operators in western Europe, Japan, and the United States. In addition, most of these reactors are located in countries that do not have national nuclear regulatory laws and independent and effective regulatory enforcement organizations.

Western safety experts generally agree that 25 of the 58 oldest Soviet-designed reactors fall well below accepted international safety standards and cannot be economically upgraded. These reactors include 15 of the type known as RBMKs and 10 VVER 440 Model 230s. The RBMKs—considered the least safe by western safety experts—and VVER 440 Model 230 reactors are believed to present the highest safety risk

because of inherent design deficiencies, including the lack of a containment structure,[2] inadequate fire protection systems, unreliable instrumentation and control systems, and deficient systems for cooling the reactor core in an emergency. Fifteen RBMKs are in operation: 2 at Chernobyl, Ukraine; 2 in Lithuania; and 11 in Russia. The 10 VVER 440 Model 230s are operating in Bulgaria (4), Russia (4), and Slovakia (2). The newer Soviet-designed reactors—VVER 440 Model 213s and VVER 1000s—have more safety features than the earlier models. For example, the VVER 1000s have containment structures similar to those in western nuclear plants. However, these reactors are operating under the same conditions—with operational deficiencies in plant management and training—as the reactors of the earliest design.

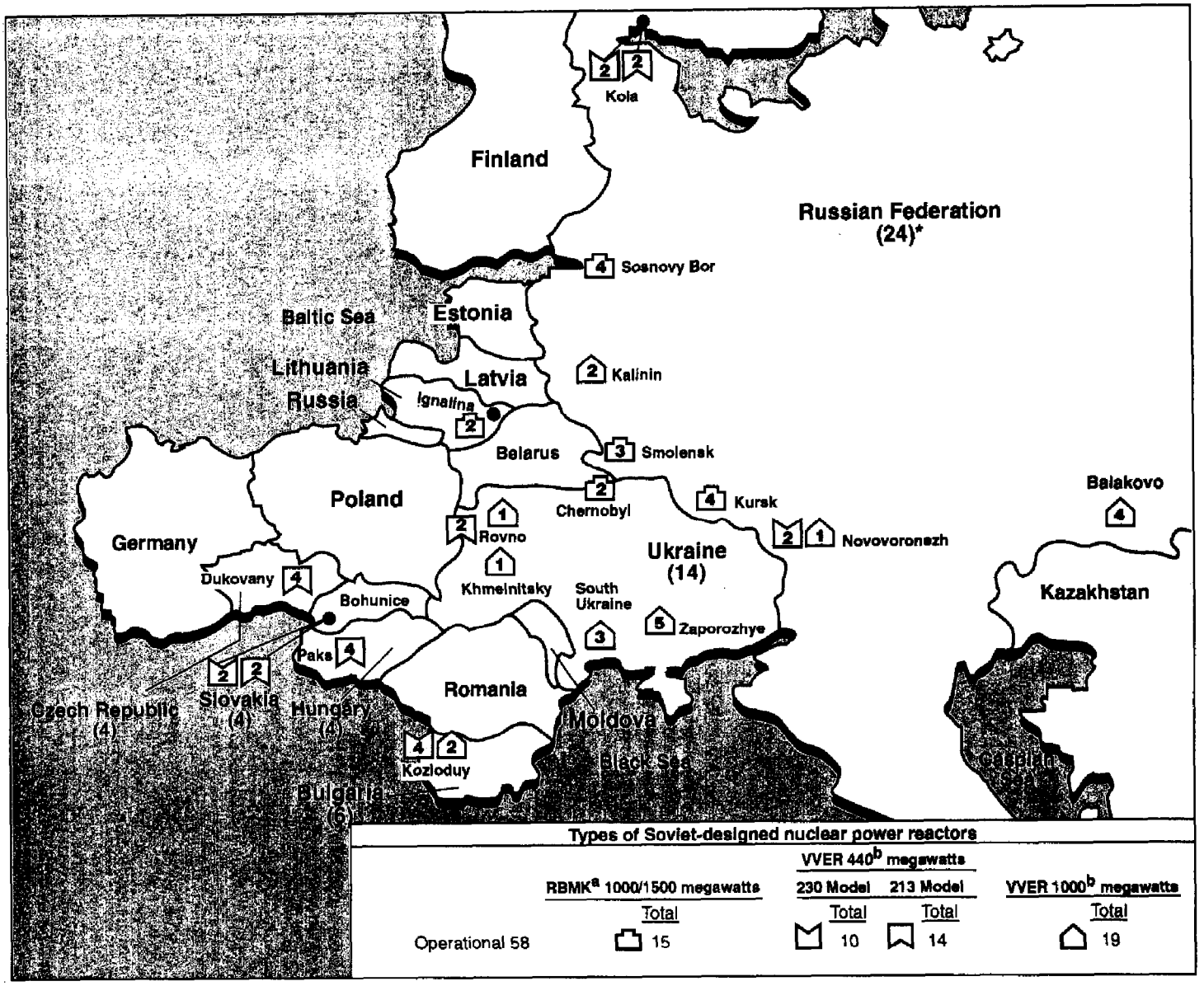
Several federal agencies share responsibility for U.S. participation in the G-7 safety assistance plan under the overall policy coordination of the Department of State's Senior Coordinator for Reactor Safety and International Science and Technology Centers. The Department of Energy (DOE) is responsible for projects involving training, operational safety, and risk reduction. These projects include short-term and longer-term improvements in fire protection, emergency core-cooling systems, backup diesel generators, and instrumentation and control systems for the RBMK and VVER 440 Model 230 and Model 213 reactors so that they can be operated more safely.

The Nuclear Regulatory Commission (NRC) is responsible for assistance to the recipient countries' regulatory organizations. The Agency for International Development transfers funds for DOE and NRC projects under interagency agreements. The Department of State leads the U.S. nuclear safety efforts in international negotiations.

Figure 1 shows the type and location of the 58 Soviet-designed reactors operating in the former Soviet Union and in central and eastern Europe.

[2]The containment structure, generally a steel-lined concrete domelike structure, serves as the ultimate barrier to the release of radioactive material in an accident.

Figure 1: Soviet-Designed Nuclear Power Plants Operating as of May 1, 1994



Note 1: Numerals within the symbols show the number of reactors, and numerals in parentheses show the total number of reactors in each country.

Note 2: *In addition, the Bilibino plant, which produces both steam and electricity, has four small-scale RBMKs producing a total of 44 megawatts, and the Beloyarsk plant has a 560-megawatt fast breeder reactor.

[a]Graphite-moderated, light-water-cooled reactor.

[b]Pressurized light-water-moderated and -cooled reactor.

International Assistance Efforts

The G-7, at its summit meeting in Munich in July 1992, addressed the complex and urgent safety problems of the Soviet-designed reactors with an emergency action plan. The plan falls into two broad categories—operational safety improvements such as training of plant personnel and near-term technical measures whereby additional equipment or enhancements of existing equipment will produce early safety benefits. The plan also called for enhancing independent regulatory authorities in the countries operating these reactors. Under this plan, over 20 countries and international organizations have pledged hundreds of millions of dollars in financial assistance to improve safety.

In general, operational safety improvements can be implemented at all plants regardless of the reactor type. The extent to which these improvements are implemented varies from plant to plant and country to country. However, the near-term technical measures are being implemented at specific reactors such as the oldest RBMKs and VVER 440 Model 230s in the hope that they will be shut down as soon as practicable. Near-term technical improvements are also planned for the newer VVER 440 Model 213 and VVER 1000 reactors, but these changes will be made to provide for longer periods of operation.

The donors are assessing (1) the feasibility of replacing the oldest and least-safe plants through the development of alternative energy sources and more efficient use of energy and (2) the potential for upgrading the safety of the reactors of more recent design. The Chairman of the NRC stated that it could take 8 to 10 years—at a cost of about $20 billion—to replace the least-safe plants with alternative sources of electricity.

The countries participating in the assistance effort are providing the bulk of the assistance through bilateral agreements with individual countries. The G-7 countries, which are the core of the Group of 24 industrialized nations (the G-24), established a Nuclear Safety Working Group within the G-24 to coordinate and avoid duplication of individual countries' assistance efforts. The G-24 established a coordination center at the European Union (EU) in Brussels, Belgium.[3] One of its initial tasks was to

[3]The European Union, formerly the European Community, consists of twelve countries: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom. It is considered a separate entity for the funding of assistance projects.

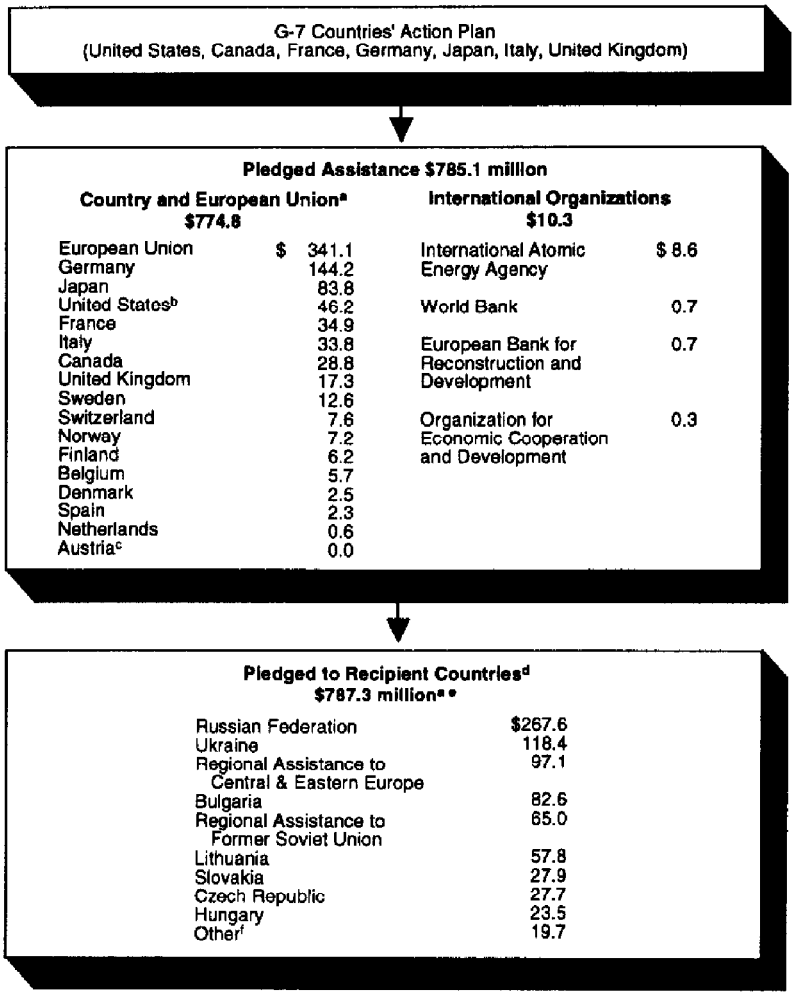
develop a data base of the international safety assistance projects. Several U.S., European, and international officials told us that the data base is of limited use because it does not contain enough detail and is incomplete. Many officials noted, however, that despite its limitations, the data base represents the most comprehensive available source of information on international assistance. (App. I summarizes the international nuclear safety assistance projects.)

The G-7 plan also called for the World Bank, the European Bank for Reconstruction and Development (EBRD), and the International Energy Agency to study possible means of using alternative energy sources to replace the least-safe nuclear power reactors. As of May 1994, 22 nations and international organizations had reported to the data base actual or planned safety assistance projects valued at approximately $785 million. Of this amount, only about 7 percent, or $57 million, represents completed projects.

The G-7 also created a multilateral fund, the Nuclear Safety Account (the Fund), directed by its donors and administered by the EBRD, to address immediate needs for safety improvement not covered in the bilateral agreements. According to the EBRD, the Fund had pledged contributions from 13 countries and the EU totaling about $157 million as of June 30, 1994. The United States has pledged $15 million to the Fund. (App. II shows the pledged contributions to the Fund.)

Figure 2 summarizes the sources and destinations of international assistance under the Fund, bilateral agreements, and commitments by international organizations as of May 1994. The major donors are the EU, Germany, Japan, the United States, France, Italy and Canada. The major recipients are the Russian Federation, Ukraine, Bulgaria, Lithuania, Slovakia, the Czech Republic, and Hungary.

Figure 2: Worldwide Sources and Recipients of International Nuclear Safety Assistance, as of May 1994



[a]Contributions to the Nuclear Safety Account are included in the pledge amounts shown for each donor country.

[b]The amount reported by the United States to the G-24 represents projects to which the United States has made commitments; it is significantly lower than the expenditures proposed by the United States, which total about $150 million.

[c]Austria has one project under way, valued at less than $50,000, that is not included because of rounding.

[d]These amounts are estimates, as the G-24 calculated the amounts assuming equal sharing of assistance in projects with multiple recipients.

[e]This amount differs from the total amount listed for the donors because it includes projects identified only as expressions of interest by the recipient countries.

[f]Other recipient countries include Armenia, Belarus, Estonia, Georgia, Kazakhstan, Kirghizia, Poland, Romania, Slovakia, Slovenia, and Uzbekistan.

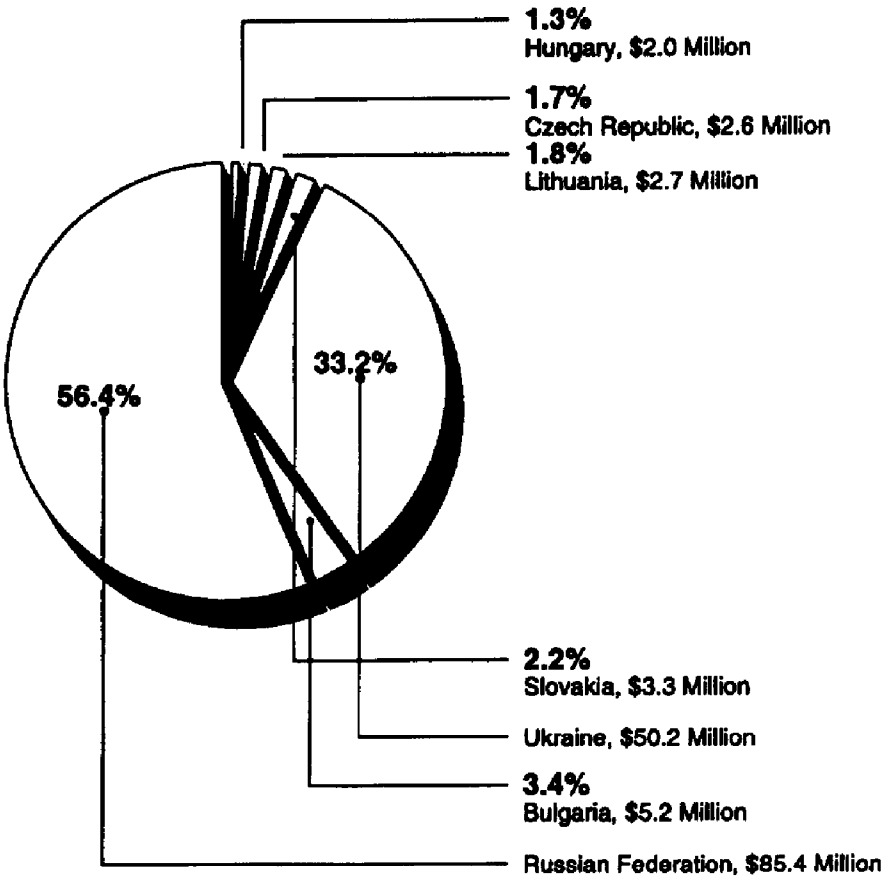
Source: GAO's analysis of information in the G-24's data base.

Planned and Ongoing U.S. Assistance

The United States plans to spend over $150 million in nuclear safety assistance in the Russian Federation, Ukraine, Bulgaria, Hungary, Lithuania, the Czech Republic, and Slovakia. (See fig. 3.) As of March 1994, about $56 million had been made available to DOE and NRC for nuclear safety assistance. Of that amount, about $18 million had been spent by the United States, including $3.3 million for delivered nuclear safety equipment and products. (App. III lists the equipment and products.) Other expenditures were for DOE headquarters' activities; DOE's and NRC's contractor personnel and travel; and support from DOE's national laboratories, which includes training and safety upgrades. The approximately $18 million also included $4 million for DOE's 2-year membership as a participant in the Institute of Nuclear Power Operations. The membership gives DOE access to the Institute's nuclear safety documents and procedures for upgrading the operational safety of Soviet-designed reactors. (App. IV lists DOE's and NRC's expenditures.)

As figure 3 shows, the bulk of the funding is targeted to Russia and Ukraine, and the remainder goes to five other countries in the region.

Figure 3: Planned Distribution of U.S. Financial Assistance of $151.3 Million by Country, as of June 30, 1994



Note: Amounts listed for individual countries do not add to $151.3 million because of rounding.

Source: GAO's illustration based on information from Brookhaven National Laboratory, DOE, and NRC.

Assistance to Russia and Ukraine

Most of the U.S. assistance program is directed to Russia and Ukraine, with the near- and mid-term objective of significantly reducing the risk of operating the older, least-safe reactors until economic conditions allow them to be shut down or until alternate sources of power can be provided. In the longer term, the program provides assistance in creating a safety culture through improvements in training and operational practices and procedures and through support in the development of independent regulatory authorities.

Specifically, the assistance focuses on

- establishing a regional training center in each country to introduce U.S. nuclear safety concepts and practices;
- implementing and extending the operational safety benefits for the VVER 440 Model 230 reactor to reactors of all other designs;
- implementing risk-reduction measures such as reliable power supply systems, fast-acting valves, and emergency water supply systems at selected RBMK and VVER 440 Model 230 reactors;
- developing nuclear infrastructure, such as a centralized emergency response capability;
- upgrading fire safety equipment and procedures at plants;[4] and
- training regulators and assisting them in developing independent regulatory agencies with the legal basis to enforce safety standards and procedures.

DOE is responsible for implementing the first five elements, and NRC is responsible for the last element.

The United States' objective in providing assistance is to channel funds toward the issues of greatest concern, such as operational safety (the development of emergency operating instructions and training materials) and fire protection. This assistance is targeted to five plants in Russia and three in Ukraine. Appendix V presents the category and funding of the United States' planned projects in Russia and Ukraine as of June 30, 1994.

Assistance to Other Countries

In Bulgaria, Hungary, the Czech Republic, Slovakia, and Lithuania, U.S. projects are focused on fire protection, plant analysis, operational safety improvements such as the development of symptom-based emergency operating instructions, and training for regulatory authorities. Appendix V also shows the category and funding of projects planned for these countries as of June 30, 1994.

Status of DOE's Initiatives

DOE is responsible for implementing most of the U.S. safety assistance program, which is focused on providing training and equipment to improve operational safety. Some Russian plant operators have been trained in maintenance and other support activities. Firefighting and fire protection equipment, such as smoke alarms, fire extinguishers, and fire hoses, have

[4]According to DOE, from 1980 to 1988 over 100 fires occurred in nuclear power plants in the former Soviet Union. In 1991, a fire in unit two at the Chernobyl plant destroyed a turbine hall and disabled the plant's safety systems.

been purchased in the United States, but at the time of our review, this equipment had not been delivered. Additional fire protection equipment, such as fire doors, will be built in the recipient countries.

DOE plans to provide more equipment over the next several years. For example, in mid-1996 the agency plans to deliver a state-of-the-art full-scope simulator for Ukraine's first nuclear regional training center; this simulator will increase the operators' technical capability to handle reactor emergencies. DOE is also planning to help the Russians establish a prototype centralized emergency response center, using a satellite communications system to link the center to two nuclear power plants. In the event of a nuclear accident, the system can provide reliable, high-speed telecommunications of voice, fax, telex, and digital information.

In 1992, DOE established a project office at the Brookhaven National Laboratory for managing the day-to-day operations of its safety assistance program. Brookhaven provides management support for subcontractors performing specific safety assistance tasks, including procuring hardware and services in the United States and the recipient countries, monitoring contracts and work, performing quality assurance and quality control, and providing technical coordination for work projects. (App. VI presents more information on Brookhaven's role in providing U.S. assistance.)

Status of NRC's Initiatives

NRC is helping develop national nuclear regulatory bodies by providing personnel with on-the-job training alongside NRC staff. NRC is conducting technical training programs at its headquarters and field offices; at the NRC Technical Training Center; and at plants in Russia, Ukraine, and to a lesser extent in countries in central and eastern Europe. NRC is also collaborating with Russian and Ukrainian regulators in assessing their inspection practices and identifying effective inspection techniques and procedures. NRC believes that such technical exchanges and training are helping to encourage an enhanced safety culture in these countries and making them better able to improve nuclear safety themselves.

According to NRC's Chairman, one of NRC's goals is to help improve the enforcement authority and political stature of Russian and Ukrainian regulators so that they command the respect of both the nuclear ministries and the utilities that operate the nuclear power plants. He believes that strong and independent regulatory bodies may eventually be capable of exercising the kind of authority over nuclear power operations in these

countries that NRC does in the United States. He said that "the shutdown of unsafe plants in these countries will ultimately depend upon the strength and independence of such regulators." He also believes that the early shutdown of the least-safe reactors is a very important measure of the United States' success in enhancing Russia's regulatory body.

Impact of International Assistance Unclear and Hampered by Philosophical and Legal Differences

While some improvements have been noted in nuclear safety in the recipient countries, the overall impact of the international assistance effort is not easily measured. The benefits of the assistance are being debated, and some nuclear experts and recipients have expressed reservations about the level, type, and suitability of the aid being provided. Liability issues are also causing delays in the delivery of assistance.

Assistance Has Provided Some Benefits, but Achievements Are Difficult to Assess

The international assistance has resulted in safety improvements at a few reactor sites, and NRC believes that the Russian regulatory body is becoming more effective as a nuclear safety regulator. In 1991, the EU allocated nearly $14 million to improve the safety of four VVER 440 Model 230 reactors in Bulgaria. The assistance included training Bulgarian personnel, cleaning and maintaining the facilities, repairing electrical wiring, establishing testing and inspection programs, and providing spare parts. Several nuclear experts who have visited the plant since these improvements were made believe that the plant is safer.

A 1992 assessment by the International Atomic Energy Agency (IAEA) noted that the international assistance had improved the safety of the Bulgarian reactors. However, an IAEA official expressed concern to us about maintaining the safety improvements in Bulgaria. He said that as the western on-site presence at the Bulgarian reactors has decreased, the Bulgarians' commitment to safety has declined. He was uncertain how to sustain the safety improvements.

NRC officials told us that the training the United States has provided to develop nuclear regulatory capability should improve safety but that it is difficult to keep a nuclear safety "report card" on these countries. While NRC can expose officials operating Soviet-designed reactors to the best regulatory practices, it is up to each country to decide whether and how to implement them. According to these officials, there is also no guarantee

that the people being trained will remain active in the countries' regulatory organizations.

NRC's Chairman has also cautioned that economic conditions in Russia and Ukraine are so severe that the long-term prospects for continued safety in the industry will be negatively affected. Plant operators are often more concerned with continuing to operate the plant to meet the demands for electricity and workers' salaries than they are with ensuring nuclear safety.

Furthermore, the impact of the safety improvements has been difficult to measure. U.S. and European nuclear safety officials believe that much of the assistance provided so far—such as assessments and training—does not lend itself to clear, measurable safety improvements. In October 1993, the U.S. Secretary of Energy noted in testimony before the Subcommittee on Energy and Power, House Committee on Energy and Commerce, that performance measurements are needed to determine the extent to which the U.S. and European assistance programs are reducing the risk of accidents.

According to a DOE official, the United States does not yet know how to measure the safety improvements made with U.S. assistance. He said that a quantitative measure comparing before-and-after results is not possible because not enough reliable data on the Soviet equipment are available to support such a comparison. This official believes that the level of safety at the reactors has increased, but he said this increase could not be quantified. He does not believe that enough improvement has been achieved in the physical plants to reduce the risk of an accident.

EU officials told us that they have not systematically evaluated the impact of their assistance because not many projects have been completed. In their view, implementing projects is more important than evaluating the program at this stage of their assistance efforts.

The Director of the IAEA's Division of Nuclear Safety believes that the assistance provided to date has improved the safety of some reactors but estimated that the donor countries would have to spend $50 million to $100 million per plant to make significant improvements in the RBMK reactors.

Disagreement Exists on the Value of the Aid Being Provided

In the view of some nuclear safety experts and representatives of the countries operating Soviet-designed reactors, the international assistance being provided (1) does not always match the needs of the plant operators and regulatory organizations, (2) is being implemented too slowly, and (3) should provide more equipment and fewer studies.

Representatives from Russia, Ukraine, and the central and eastern European countries were critical of the EU's programs, which provide the largest segment of the assistance. In their view, the EU's process for delivering assistance is too cumbersome. Some also believe that the programs are commercially motivated, providing benefit to western contractors rather than improving nuclear safety in the recipient countries.

EU officials told us that most of the western European assistance has been spent on studies or preliminary evaluations. In their view, these studies were necessary to (1) assess the condition of the reactors, (2) set priorities for assistance, and (3) identify needed improvements in the techniques used for managing the plants. EU officials noted that while their programs were initially intended primarily to provide technical assistance, the programs are increasingly shifting towards implementing concrete projects to improve safety, such as the delivery of equipment. One EU official also said that the countries receiving assistance had unrealistic expectations and that some countries, particularly Russia, prefer financial assistance with "no strings attached."

Other officials, including the Director and Deputy Director of the IAEA's Division of Nuclear Safety, said that the recipient countries do not need additional studies of safety problems—because the deficiencies have already been well documented—but are in urgent need of equipment and other hardware to help reduce the risk of an accident. Representatives of some recipient countries confirmed that although some of the studies are useful, they need more practical assistance.

Representatives from Russia, Hungary, Ukraine, the Czech Republic, and Slovakia told us that some bilateral programs administered by France, Germany, Sweden, the United States, and the IAEA were useful. They identified the U.S. NRC's programs as beneficial because they provided timely training to personnel performing regulatory inspections. In September 1993, the Chairman of Russia's regulatory organization told G-24 representatives that the bilateral assistance programs being

implemented with these countries were timely and effective compared with other western assistance.

According to NRC's Chairman, until the infrastructure is in place to bring the safety of Soviet-designed reactors up to acceptable levels or to identify alternative energy sources so that the least-safe reactors can be shut down, no significant amounts of commercial investment in electricity will flow into the countries of the former Soviet Union. Furthermore, unlike NRC, the Russian nuclear safety and regulatory agency, Gosatomnadzor (GAN), is not supported by national nuclear legislation in carrying out its regulatory responsibilities. GAN can order facilities closed only when it is able to demonstrate that an accident is pending or very likely to occur.

An NRC official said that enactment of a proposed international nuclear safety convention could help sustain the recipient countries' commitment to safety.[5] This convention—the idea of which was launched at an IAEA safety conference in 1991 to codify certain basic safety principles to which all countries could be held accountable—was expected to be ready for signature at the IAEA's September 1994 General Conference. It provides for periodic peer review of countries' compliance with generally accepted international nuclear safety principles. In October 1993, NRC's Chairman noted in congressional testimony that the convention is one way to bring international pressure on countries that do not pay adequate attention to safety issues.[6]

Absence of Liability Protection Is a Major Obstacle to Furnishing Assistance

Efforts by the United States and other donors to provide more equipment and technical services have also been delayed because the major countries operating Soviet-designed reactors—Russia and Ukraine—have been unable to satisfy western contractors' concerns about protection from liability. According to a State Department attorney, contractors worry that they could be found liable for damages, especially in U.S. courts, if an accident occurred at a Soviet-designed nuclear power plant where they have furnished equipment or performed work. According to the attorney, a nuclear accident that caused substantial property damage and personal injury could result in financial liability for any company that provided equipment or services to the plant. In the event of an accident, the

[5]See Nuclear Safety: Progress Toward International Agreement to Improve Reactor Safety (GAO/RCED-93-153, May 14, 1993).

[6]U.S. Efforts to Improve the Safety of Soviet-Designed Nuclear Reactors, statement before the Subcommittee on Energy and Power, House Committee on Energy and Commerce (Oct. 28, 1993).

company could face enormous expenses to litigate or settle liability claims.

In the United States, the Price-Anderson Act, as it amends the Atomic Energy Act of 1954, (1) ensures that victims of nuclear damage will be compensated if an accident occurs at a nuclear power plant and (2) sets a limit on private industry's liability. In addition, owners of nuclear power plants carry property damage insurance and provide suppliers with a waiver of liability for both direct and consequential damages in the event of an accident. U.S. contractors are seeking similar protection for the work they perform on Soviet-designed reactors.

Many other western countries operating nuclear power plants are party to international agreements that also assign liability to the owner of the nuclear power plant, typically a utility company. These agreements allow governments to limit the amounts for which the power plant owner can be held liable. Several countries operating Soviet-designed reactors are not parties to the international liability agreements, nor do they have separate domestic liability laws (except Lithuania). (App. VII describes the applicable conventions and shows the status of nuclear liability agreements in the recipient countries.)

The major donor countries are attempting to resolve the liability issue. In late 1993, the United States signed bilateral safety assistance agreements with Russia and Ukraine containing provisions on liability. The agreements state that in the event of an accident, the Russian and/or Ukrainian governments will indemnify the U.S. government and its contractors for third-party claims for damages resulting from a nuclear accident at nuclear power plants where the U.S. government or its contractors provided equipment or performed work.

According to DOE and State Department officials, most U.S. contractors are not satisfied that the government-to-government agreements provide adequate liability protection because these agreements are not considered directly enforceable in court by the contractors. The contractors believe they would have to rely on the U.S. government to secure their rights. In April 1994, the Associate Director of Brookhaven National Laboratory told us that the Board of Directors of Associated Universities, Inc., the organization that operates Brookhaven for DOE, had decided not to undertake risk-reduction work in the former Soviet Union because Brookhaven did not have adequate liability protection. Many of the architectural and engineering firms that Brookhaven selected to perform

the design and inspection work on Soviet-designed reactors are also refusing further work until liability protection is provided.

In June 1994, one U.S. contractor announced that it was willing to proceed with nuclear safety projects if the U.S. government would provide assurances that the United States would seek to enforce the liability agreements and, if necessary, consider helping the contractor deal with nuclear damage claims that might be filed in U.S. courts. As of July 1994, the U.S. government had not furnished a letter of assurance to the contractor.

In the view of an official from the Organization for Economic Cooperation and Development's (OECD) Nuclear Energy Agency, the most satisfactory long-term solution is for recipient countries to enact nuclear liability laws and become parties to the international agreements. The official noted that doing so may be a difficult and time-consuming process because many of the countries (1) are unfamiliar with the legal concepts involved, (2) need to develop liability laws and governmental structures to implement them, and (3) may have other national priorities.

Shutdown of Highest-Risk Reactors Remains an Elusive Goal

Although the United States and other donors agree that the highest-risk nuclear power reactors should be shut down as soon as practicable, there are no guarantees that any will be closed in the near future. Furthermore, recipient countries that depend on the reactors for domestic energy and export income are unlikely to shut down the reactors without viable alternative options for energy supplies.

Agreements on Closure May Not Be Honored

The donor countries, including the United States, believe that the EBRD-administered multilateral nuclear safety fund is the appropriate instrument for linking assistance to plant closure. Although the EBRD has negotiated such agreements with Bulgaria and Lithuania, the conditions for closure are tenuous.

For example, while Bulgaria agreed to a phased shutdown of its highest-risk reactors by 1998 in exchange for a $28 million grant for equipment, Bulgaria's commitment hinges on the availability of adequate replacement energy, which is still being developed. Similarly, in return for a $38 million grant, Lithuania agreed to stop producing electricity at one of its two RBMK units by mid-1998 unless a new operating license is granted by the Lithuanian safety authority. Continued operation of the reactor will

depend upon the cost of further safety improvements and the country's energy situation. A European official told us that these agreements satisfy political concerns but may prove difficult, if not impossible, to fulfill.

Not only are the highest-risk reactors not being shut down, but some U.S. and European officials are concerned that the assistance may be used by the recipients to justify the continued operation of these reactors. According to the Director of the IAEA's Division of Nuclear Safety, unless the recipient countries have viable sources of alternative energy, there is little else they can do. In his October 1993 congressional testimony, NRC's Chairman said that it is difficult to draw a fine line between short-term safety improvements and upgrades that could encourage a plant operator to think in terms of long-term life extension.[7]

Obtaining Commitment to Close Down Highest-Risk Reactors Is Difficult

Closing the Soviet-designed reactors is a complex and formidable challenge. Countries operating these reactors depend, to varying degrees, on nuclear power to meet their domestic energy requirements. In 1993, the nuclear share of electricity production averaged 10 percent in Russia, 30 percent in Ukraine, and 60 percent in Lithuania. Some of the countries also rely on nuclear power as a source of revenue. In 1992, 15 percent of Lithuania's exports were in the form of nuclear-generated electricity.

These countries' reliance on nuclear power is illustrated by Ukraine's decision to continue to operate two RBMK units at Chernobyl and possibly restart a third unit that was damaged in a 1991 fire, even though the Ukrainian Parliament had previously agreed to close down the entire installation by December 31, 1993. The IAEA has recommended to the President of Ukraine that the Chernobyl nuclear power reactor not be operated because of, among other things, the loss of skilled personnel and the fact that there is no place to store additional spent (used) nuclear fuel. Ukrainian representatives told western nuclear safety officials that Ukraine's decision was unavoidable because of domestic energy requirements. In addition, Armenia, because of its energy needs, plans to restart two VVER 440 Model 230 reactors that were shut down following an earthquake in 1988. Russia has agreed to help with this effort.

Donor countries and some of the recipient countries also fundamentally disagree about plant safety. For example, while there is broad agreement in the West about what needs to be done to address Russian nuclear safety

[7]Russia has recently signed an agreement with the United States that could lead to the closure of the three plutonium production reactors in Russia. However, these three reactors are not among the 25 highest-risk nuclear power reactors discussed in this report.

problems, there is no such consensus among Russian nuclear officials. Russia, which operates 15 of the 25 highest-risk reactors, has periodically challenged western assumptions about the safety of its reactors. Russian authorities do not accept western judgments that the RBMKs and VVER 440 Model 230s pose significant inherent risks that require prompt shutdown. Russian officials have described the possibility of closing the country's RBMK reactors as "pure fantasy." In February 1993, a high-level Russian official told a State Department delegation that Russia was unable to close plants that were regarded as unsafe by the West. He reaffirmed his government's position that nuclear power is an essential element of Russia's energy program and noted that expanding nuclear power is essential if Russia is to meet its future energy needs.

Recent Study Indicates Feasibility of Closing Highest-Risk Reactors

A 1993 study of six countries[8] conducted by the World Bank, the EBRD, and the OECD's International Energy Agency concluded that, under one possible scenario, it would be technically feasible to shut down the highest-risk reactors in these countries and replace them with alternate energy sources by the mid- to late-1990s. The study estimated that, under this approach, it would cost approximately $21 billion to replace these reactors. However, for various reasons—including economic, social, and environmental considerations—the study noted that the affected countries would not favor shutting down the highest-risk reactors quickly. The study also noted that many officials in these countries do not share the same concerns about the safety of the highest-risk plants as their western counterparts.

Many international nuclear safety officials recognize that closing the highest-risk reactors will require an integrated, long-term energy strategy. Several of these officials noted that nuclear safety assistance is one component of a larger effort that must include market reforms, adjustments in energy pricing, and the identification of suitable replacement forms of energy—both nuclear and nonnuclear—in the recipient countries. The G-7 has asked the international financial institutions, under the leadership of the World Bank, to undertake further independent efforts to help each country develop its own energy strategy, taking nuclear safety into account.

The United States and Russia are conducting a joint study to examine options for Russia's future electric power using both nuclear and nonnuclear options. The study will look at possible sources of power;

[8]Nuclear Safety and Electric Power in Armenia, Bulgaria, Lithuania, Russia, Slovakia, and Ukraine (June 1993).

transmission improvements; energy efficiency; and the environmental, safety, and financing aspects. The study's interim report was completed in time for the July 1994 G-7 summit meeting in Italy; the final report is scheduled to be completed by the end of 1994.

Observations

To reduce the risk of another major nuclear power plant accident, the United States and other nations have pledged hundreds of millions of dollars to the difficult and costly task of upgrading the safety of Soviet-designed reactors and improving the safety culture in the host countries. However, these countries are providing assistance without a commitment from all the recipient countries to close down the highest-risk reactors on a mutually agreed timetable. In fact, in the absence of a commitment to close down the reactors, the assistance may encourage their continued operation. Donor countries face formidable challenges in promoting the closure of the Soviet-designed reactors because the countries operating them depend on nuclear power to meet their domestic energy and export needs. Furthermore, in many instances the donor and recipient countries fundamentally disagree about the safety of these reactors.

Because economic conditions are poor in these countries and alternative energy options are not yet available, it appears unlikely that any reactors will be shut down in the short term. Therefore, trying to help them operate more safely until they can be closed appears to be a reasonable international course of action.

Most of the bilateral assistance promised has yet to be delivered. The question of liability is a major impediment to providing some assistance. As of July 1994, the United States and other western countries had not been able to resolve this matter satisfactorily with contractors: It appears that Brookhaven, the contractor managing the U.S. assistance for DOE, and the firms selected to perform design and inspection work may either withdraw from the program or limit the scope of their work unless additional liability protection is provided.

If the liability issue is resolved, and as the United States increases its nuclear safety assistance, it will be important to demonstrate that the assistance is improving the safety of the Soviet-designed reactors. In the absence of performance-based criteria to measure and evaluate the effect of the assistance, the proposed international nuclear safety convention may provide a useful forum for experts from various countries to review

progress in achieving and sustaining increased levels of safety at these nuclear plants.

Agency Comments

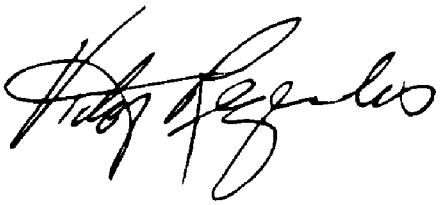
We discussed the facts presented in this report with the State Department's Deputy Senior Coordinator for Nuclear Safety Assistance, the Director of DOE's International Programs Division, the Director of NRC's Office of International Programs, and the project manager at the Brookhaven National Laboratory. We also discussed these facts with officials from the EU, EBRD, and IAEA. In general, these officials agreed with the facts presented. They gave us additional clarifying information, and we revised the text where appropriate. However, as requested we did not obtain written agency comments on a draft of this report.

To address our objectives, we interviewed officials and reviewed documentation from the Department of State, DOE, NRC, and Brookhaven National Laboratory. We met with officials from some of the countries operating Soviet-designed reactors, such as Russia and Ukraine. We also met with officials from international organizations actively working to improve nuclear reactor safety, including the IAEA and the EBRD. Our scope and methodology are discussed in detail in appendix VIII.

We performed our review between June 1993 and July 1994 in accordance with generally accepted government auditing standards.

We plan no further distribution of this report until 30 days from the date of this letter unless you publicly announce its contents earlier. At that time, we will send copies to the Secretaries of State and Energy, the Chairman of NRC, the Administrator of the Agency for International Development, the Director of the Office of Management and Budget, and other interested congressional committees. We will also make copies available to others on request.

Please call me at (202) 512-3841 if you or your staff have any questions. Major contributors to this report are listed in appendix IX.



Victor S. Rezendes
Director, Energy and
Science Issues

Contents

Figures

Abbreviations

AID	Agency for International Development
DOE	Department of Energy
EBRD	European Bank for Reconstruction and Development
ECU	European currency unit
EU	European Union
GAN	Gosatomnadzor
GAO	General Accounting Office
IAEA	International Atomic Energy Agency
NRC	Nuclear Regulatory Commission
OECD	Organization for Economic Cooperation and Development
VNIIAES	All-Russion Research Institute for Nuclear Power Plant Operators

International Nuclear Safety Assistance Projects, as of March 1994

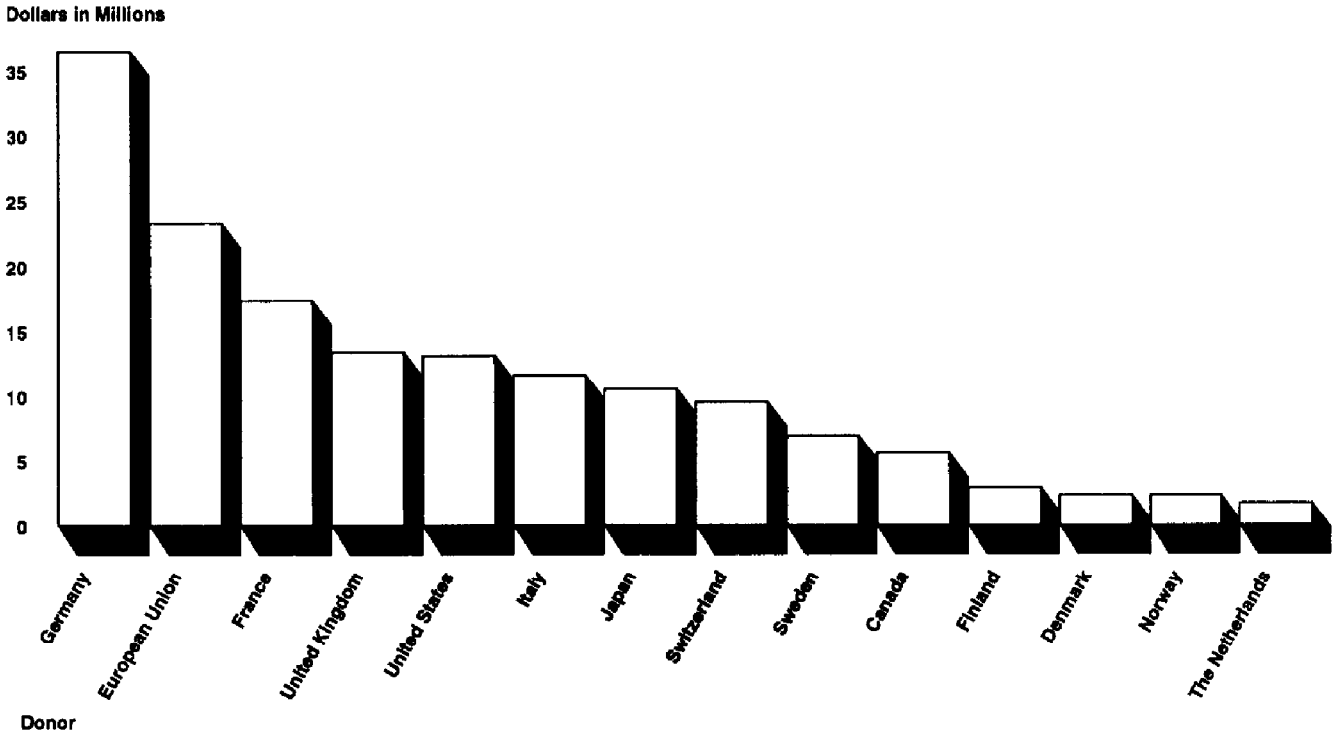
Project type	Number of projects
Training of personnel	124
Safety assessments/safety evaluation reports	117
Proposals for safety upgrades of equipment or structures	102
Production or supply of equipment	101
Improving methodologies related to training, operations, and maintenance	91
Information exchanges, including written materials, visits, and conferences	65
Theoretical or experimental safety research reports	57
Improving procedures related to maintenance, operations, and testing	48
Projects related to periodic testing of nuclear facilities	29
Arrangements to provide maintenance at nuclear facilities	6
Other[a]	89
Unknown/unspecified	65
Total[b]	**894**

[a]Other projects include International Atomic Energy Agency safety review missions, radioactivity studies, and assessments of radioactive waste treatment.

[b]Projects may include multiple activities. As a result, the total number of projects listed (894) exceeds the number of projects listed in the data base (568).

Source: G-24's data base.

Pledged Contributions to the Multilateral Nuclear Safety Fund, as of June 30, 1994



Source: European Bank for Reconstruction and Development.

U.S. Nuclear Safety Equipment and Products Delivered to Countries Operating Soviet-Designed Reactors, as of March 1994

Country	Location	Project	Value
Bulgaria	Kozloduy	Plant analyzer	$150,000
Bulgaria	Kozloduy	Computer software	23,000
Bulgaria	Kozloduy	Fire trucks and equipment	500,000
Subtotal			**$673,000**
Russia	Kola	Leak sealant and equipment	200,000
Russia	Smolensk	Sample fire doors and sealant equipment	20,000
Russia	Balakovo	Office equipment	160,000
Russia	Balakovo	Training tools	25,000
Russia	Balakovo	Soldering equipment (training)	40,000
Russia	Balakovo	Instrumentation training	400,000
Russia	Balakovo	Training course	400,000
Russia	Balakovo	Safety training	100,000
Russia	Balakovo	Simulator maintenance training	25,000
Russia	Balakovo	Simulator software training	50,000
Russia	Balakovo	Office equipment	42,000
Russia	Balakovo	Needs analysis	100,000

(continued)

Country	Location	Project	Value
Subtotal			**$1,562,000**
Ukraine	Zaporozhye	Simulator maintenance training	25,000
Ukraine	Zaporozhye	Training tools	25,000
Ukraine	Zaporozhye	Sample fire doors and detectors	5,000
Ukraine	Zaporozhye	Fire protection equipment	45,000
Ukraine	Unspecified	Training course	50,000
Ukraine	Khmelnitsky	Maintenance course	400,000
Ukraine	Khmelnitsky	Control room reactor training	450,000
Ukraine	Khmelnitsky	Needs analysis	100,000
Subtotal			**$1,100,000**
Total			**$3,335,000**

Source: Based on data from the Brookhaven National Laboratory and DOE.

DOE's and NRC's Expenditures, as of March 1994

Dollars in Thousands

Expenditure	Amount
DOE	
Headquarters activities	$460
Travel	153
Associate membership in the Institute of Nuclear Power Operations to obtain symptom-based emergency operating instructions	4,500
Brookhaven National Laboratory contracts	9,401[a]
Argonne National Laboratory support	1,823
DOE/Brookhaven Area Office support	23
Pacific Northwest Laboratory support	47
Subtotal	**$16,407**
NRC	
Contractor personnel	$515
Travel	696
Training	125
Equipment	117
Other costs	7
Subtotal	**$1,460**
Total	**$17,867**

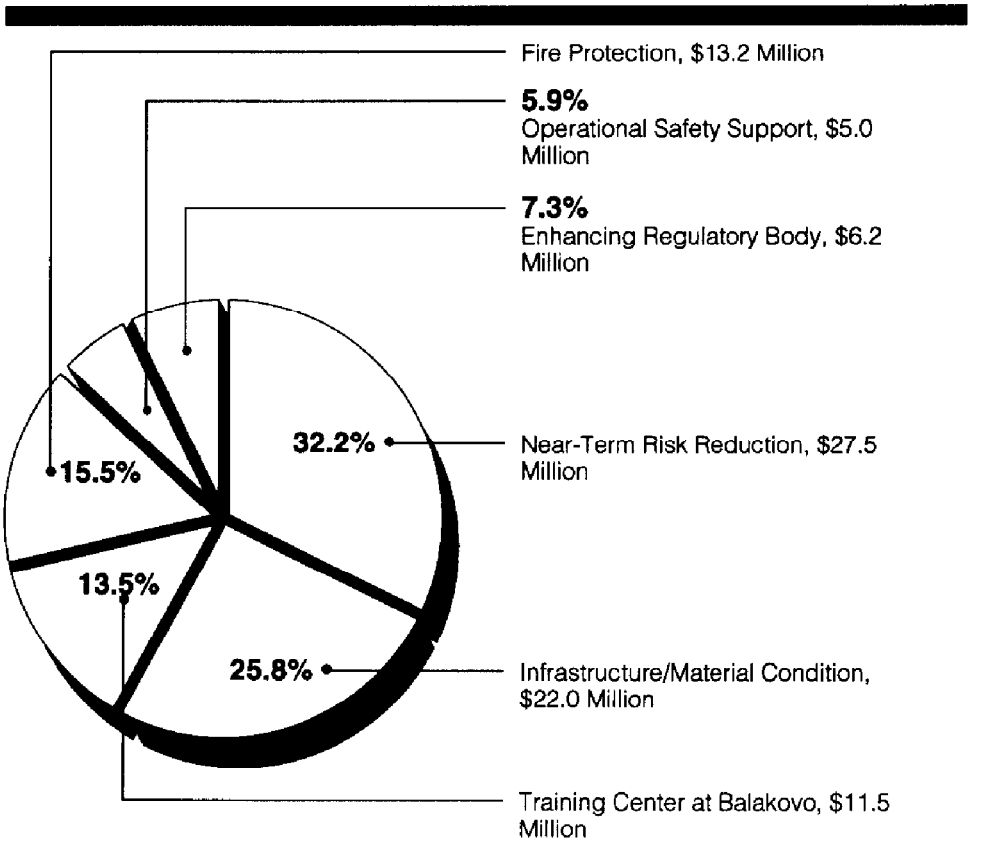
[a]Includes about $3.3 million in nuclear safety equipment and products delivered to countries operating Soviet-designed reactors.

Source: Compiled from DOE and NRC data.

Planned Distribution of U.S. Funding to Countries With Soviet-Designed Reactors

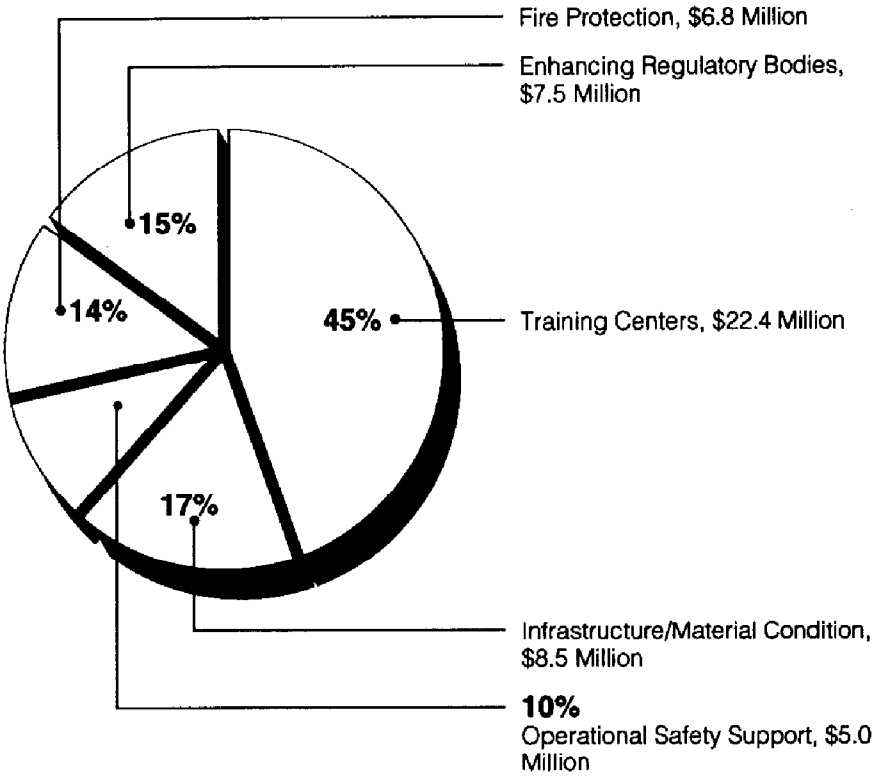
Figures V.1, V.2, and V.3 show the planned distribution by activity of U.S. funding in the amount of $85.4 million for the Russian Federation; in the amount of $50.2 million for Ukraine; and in the amount of $15.8 million for countries in central and eastern Europe.

Figure V.1: Planned Distribution of U.S. Funding Totaling $85.4 Million for the Russian Federation, as of June 30, 1994



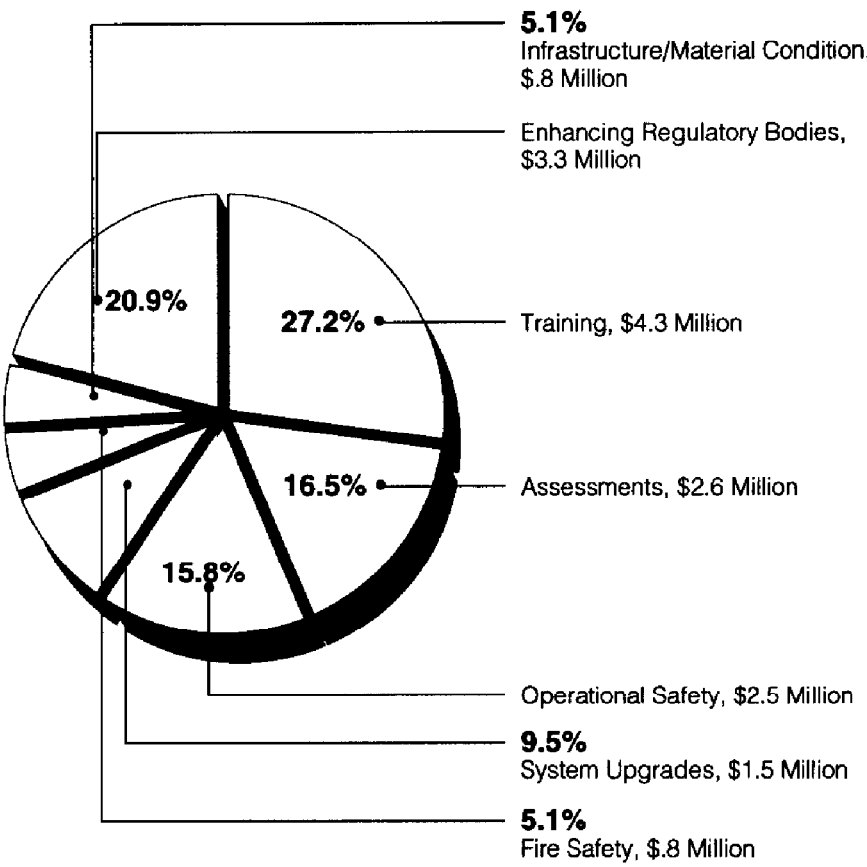
Source: Based on data from the Brookhaven National Laboratory, DOE, and NRC.

Figure V.2: Planned Distribution of U.S. Funding Totaling $50.2 Million for Ukraine, as of June 30, 1994



Source: Based on data from the Brookhaven National Laboratory, DOE, and NRC.

Figure V.3: Planned Distribution of U.S. Funding Totaling $15.8 Million for Central and Eastern European Countries, as of June 30, 1994



Source: Based on data from the Brookhaven National Laboratory, DOE, and NRC.

How the United States Is Managing Its Nuclear Safety Assistance

The United States is managing the safety assistance program from Washington, D.C., under an interagency agreement in which the U.S. Agency for International Development (AID) funds the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) for implementing nuclear safety initiatives in the former Soviet Union and in central and eastern Europe. The decision to manage the program in this manner, rather than from U.S. missions located in the recipient countries, is a departure from AID's usual practice for delivering foreign aid. U.S. officials said the rationale for this decision was based on several factors: (1) the short-term nature of the program did not justify establishing AID or other DOE and NRC technical missions in the recipient countries; (2) the State Department's Senior Coordinator and DOE's and NRC's technical experts on nuclear safety are located in Washington; and (3) the U.S.-based private firms and organizations, national laboratories, and consultants through which the program is being implemented are located in the United States and can be more easily managed from Washington.

In 1992, DOE established a project office for managing the day-to-day operations of its safety assistance programs at the Brookhaven National Laboratory in Upton, New York. Brookhaven is responsible for providing management support for the technical contracts under which subcontractors perform specific safety assistance tasks. This support includes procurement of hardware and services from sources in the United States and the recipient countries, monitoring of contracts and work, quality assurance and quality control, and technical coordination of work projects.

Brookhaven Plans to Contract Directly With Russian Nuclear Power Plants to Complete Projects

In an effort to respond directly to the most urgent safety needs of Russia and Ukraine, Brookhaven plans to contract directly with these countries' nuclear power plants. It also plans to contract with the All-Russian Research Institute for Nuclear Power Plant Operations (VNIIAES) to supply engineering support for training centers, simulators, and operational safety at nuclear power plants where VVER and RBMK reactors are in place. Brookhaven's project manager for the Nuclear Safety Initiative told us that this approach is cost-effective for the U.S. program and will allow the recipient plants, which would be best motivated, to take responsibility and implement operational safety measures and near-term measures to reduce risk.

Brookhaven also plans to establish a project office in Russia. According to Brookhaven officials, the office's staff will function primarily as a

coordinating body. It will be staffed primarily by Russians; one U.S. official will be hired by Brookhaven. According to DOE, the U.S. official will serve primarily as a liaison and coordinator. Brookhaven plans to contract with Russia's state-owned utility, Rosenergoatom, which is responsible for operating nuclear power stations, to provide for support services and coordination within Russia in this office.

The scope of the work, price of the contracts, and responsibilities of the parties for each task will be negotiated between Brookhaven on the one side and each plant and Russia's VNIIAES on the other. The plants and VNIIAES will provide the personnel, equipment, facilities, materials, and services necessary to perform the work. Brookhaven may also provide information and equipment. The United States, Russia,and Ukraine have formed a joint management committee to perform program planning and management as well as to select staff to carry out the work programs.

Contract Payment Will Not Be Based on Cost Data

Brookhaven plans to place task-order contracts with the power plants and VNIIAES and negotiate a fixed dollar price for a given scope of work. It does not intend to use a detailed cost estimate prepared by these organizations to justify the final price for the work to be performed. Rather, it plans to use its experience on similar work in the United States to set a benchmark for the cost of the work.

According to Brookhaven's project manager, the prevailing business, political, and social conditions in Russia and Ukraine render efforts to have these organizations prepare detailed cost estimates in support of task-order bid prices of little or no value. Because of past business practices under the communist government, there is no readily accessible or reliable data base on costs that can be used to judge the acceptability of the cost estimates developed.

The project manager also believes that it would take considerable time and effort to get the power plants and VNIIAES to respond in any meaningful way to requests for such estimates. Because these countries do not follow standard accounting practices, he believes Brookhaven would get a different pricing approach from each organization. In the United States, the value of the services Brookhaven plans to buy is determined by the marketplace, but no such determinant exists in these countries. Furthermore, on the basis of a generally negative experience within the industry, Brookhaven will not try to pay employees on the basis of a guess as to what they are currently being paid.

Brookhaven cited a recent experience to illustrate the problem. For similar work, a Russian design institute, insisted that as the contractor it be paid $12,000 per man-year, while a Ukrainian scientific institute would do the work for about $100 per man-month. Brookhaven, along with DOE program management, has determined that it would be unwise to set a precedent by negotiating hourly labor rates because this is a sensitive social issue. Brookhaven believes that by negotiating fixed-price contracts, it can get a better price and avoid dealing with the social issue of wage rates.

The DOE program manager told us that DOE has approved the guidelines he developed for establishing reasonable cost estimates when contracting with Russian or Ukrainian firms. The guidelines allow DOE to approve Russian cost estimates as long as they do not exceed the cost of performing the contract in the United States.

International Nuclear Liability Agreements and Status of Liability Coverage in Countries Operating Soviet-Designed Reactors

Two international conventions regulate liability for nuclear damage to persons and property. The first is the Convention on Third-Party Liability in the Field of Nuclear Energy (the Paris Convention, 1960), which applies to 14 European countries. The second is the similar Convention on Civil Liability for Nuclear Damage (the Vienna Convention, 1963), which currently applies to 24 parties. The goal of these conventions is to ensure rapid, adequate, and equitable forms of compensation for victims of a nuclear accident. The conventions ensure that the responsibility for damages caused by a nuclear accident is channeled to the plant operator, typically a public utility.

According to a September 1993 document from OECD's Nuclear Energy Agency, although the Paris and Vienna conventions are similar, they do not provide a single, uniform third-party liability regime for all the countries that are parties to either convention. Until 1992, the two conventions operated in isolation from each other, so that each convention benefited only victims within the territory of its own parties. For example, damage occurring in the territory of a party to the Paris Convention, caused by an accident in a country that is a party to the Vienna Convention, would not be covered by either convention. No country is a party to both conventions because of the potential conflicts involved in their simultaneous application. This significant gap in the protection of victims was lessened by a joint protocol that links the two conventions.

The 1988 Joint Protocol on Civil Law Liability and Compensation for Cross-Boundary Damage From Nuclear Accident established a link between the 1960 Paris Convention (which covers most West European countries) and the Vienna Convention (which has worldwide coverage). Since the protocol entered into force in 1992, parties to it are treated as though they were parties to both conventions. The liability of an operator and the amount of that liability are still determined by the convention that covers the country where the operator's installation is located. The protocol resolves potential conflicts between the two conventions, particularly in the case of transport, by ensuring that only one convention applies to any accident. There are currently 16 parties to the joint protocol.

The accident at Chernobyl highlighted the need to modernize and strengthen the Vienna and Paris conventions. Since 1986, the International Atomic Energy Agency has served as one forum for many aspects of international nuclear liability, with a view toward establishing a comprehensive international regime that would obtain broad adherence. A

number of proposals to amend the Vienna Convention are currently being considered.

With the exception of Lithuania, none of the countries with the highest risk RBMK and VVER 440 Model 230 nuclear power reactors is party to the Vienna Convention or the joint protocol. Table VII.1 shows the status of nuclear liability coverage in the countries operating Soviet-designed reactors.

Table VII.1: Nuclear Liability Regime in Countries Operating Soviet-Designed Reactors, as of March 23, 1994

Country	National legislation?	Party to Vienna Convention?	Party to Joint Protocol?
Russia[a]	Under preparation	No	No
Ukraine[a]	Under preparation	No	No
Lithuania	Yes	Yes	Yes
Bulgaria[b]	Under preparation	Under preparation	Under preparation
Czech Republic	Under preparation	Yes	Yes
Slovakia	Expected end of 1994	No	No
Hungary	Revision of existing legislation under preparation	Yes	Yes

[a]Signed a bilateral agreement on nuclear liability with the U.S. government.

[b]A copy of the Bulgarian regulation guaranteeing liability protection is annexed to each contract.

Source: Based on data from the G-24's Nuclear Safety Coordination Committee.

Scope and Methodology

To assess U.S. and international efforts to provide assistance to improve the safety of nuclear power reactors in the former Soviet Union and in central and eastern Europe and to evaluate the impact of and impediments to providing the assistance, we interviewed and obtained documentary information from officials at the U.S. Department of State, Department of Energy (DOE), and Nuclear Regulatory Commission (NRC). We also met with officials of the Brookhaven National Laboratory in Upton, New York, to review how specific safety projects were being carried out on behalf of DOE.

As requested, we did not obtain written agency comments on a draft of this report. However, DOE, State Department, and NRC officials generally agreed with the facts in this report. They offered technical clarifications, which we incorporated where appropriate.

To obtain information on what further action is needed to improve nuclear safety, we met with officials of the Institute of Nuclear Power Operations and the World Association of Nuclear Operators in Atlanta, Georgia. We also met with officials of the Electric Power Research Institute in Palo Alto, California. In addition, we interviewed a number of nuclear safety experts in private industry.

To determine the amount and type of assistance being planned or provided to improve the safety of Soviet-designed reactors, we obtained data from the G-24's Nuclear Safety Assistance Coordinating Center in Brussels, Belgium. This organization is responsible for developing a data base for international nuclear safety assistance. We did not independently verify the accuracy and completeness of the data provided by the G-24. We converted all of the funding data from European currency units (ECU) to U.S. dollars, using an exchange rate of 1 ECU equals $1.163.

To identify perceptions about the benefits and limitations of the assistance and efforts to coordinate international assistance, we interviewed officials and obtained documentation from several international organizations. Specifically, we met with officials from the International Atomic Energy Agency (IAEA) (Vienna, Austria), OECD's Nuclear Energy Agency and International Energy Agency (Paris, France); the World Association of Nuclear Operators (Paris and London centers); the European Bank for Reconstruction and Development (EBRD) (London, England); and Euratom (Luxembourg). We also met with several representatives of Europe's nuclear industry to obtain their views on the safety of Soviet-designed reactors and liability issues.

We also met with or obtained information from donor and recipient countries and organizations. Donors' views were obtained from the European Union and from representatives to IAEA from Japan, Germany, and Sweden. We also met with nuclear safety officials from France and the United Kingdom. We received information from representatives of the following countries that are operating Soviet-designed reactors: Bulgaria, the Czech Republic, Hungary, the Russian Federation, Slovakia, and Ukraine.

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.	Jim Wells, Associate Director Gene Aloise, Assistant Director Thomas J. Flaherty, Evaluator-in-Charge Duane G. Fitzgerald, Ph.D., Nuclear Engineer
European Office	Glen Levis, Site Senior Pamela J. Timmerman, Senior Evaluator

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