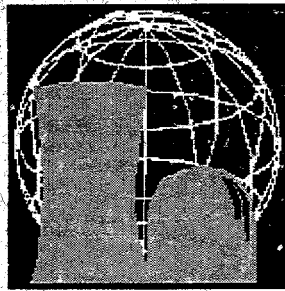


# Pacific Northwest National Laboratory

Operated by Battelle for the  
U.S. Department of Energy

## Summary of the Contractor Information Exchange Meeting for Improving the Safety of Soviet-Designed Nuclear Power Plants February 19, 1997



April 1997

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Prepared for the U.S. Department of Energy  
under Contract DE-AC06-76RLO 1830

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# 1.0 Introduction

This report summarizes a meeting held on February 19, 1997, in Washington, D.C. The meeting was held primarily to exchange information among the contractors involved in the U.S. Department of Energy's efforts to improve the safety of Soviet-designed nuclear power plants. Previous meetings have been held on December 5-6, 1995, and May 22, 1996. The meetings are sponsored by the U.S. Department of Energy and coordinated by the Pacific Northwest National Laboratory.<sup>(a)</sup>

The U.S. Department of Energy works with countries to increase the level of safety at 63 Soviet-designed nuclear reactors operating in Armenia, Bulgaria, the Czech Republic, Hungary, Lithuania, Russia, Slovakia, and Ukraine. The work is implemented largely by commercial companies and individuals who provide technologies and services to the countries with Soviet-designed nuclear power plants.

Attending the meeting were 71 representatives of commercial contractors, the U.S. Department of Energy, the U.S. Department of State, national laboratories, and other federal agencies (see Appendix B).

The presentations and discussions that occurred during the exchange are summarized in this report. While this report captures the general presentation and discussion points covered at the meeting, it is not a verbatim, inclusive record. To make the report useful, information presented at the meeting has been expanded to clarify issues, respond to attendees' requests, or place discussion points in a broader programmatic context. Appendixes A through F contain the meeting agenda, list of attendees, copies of presentation visuals and handouts, the Strategy Document discussed at the meeting, and a summary of attendees' post-meeting evaluation comments.

As with past information exchanges, the participants found this meeting valuable and useful. In response to the participant's requests, a fourth information exchange will be held later in 1997.

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## 2.0 Improving the Safety of Soviet-Designed Nuclear Power Plants: Direction and Updates

*Speaker: Kristen Suokko; Associate Director for International Programs; Office of Nuclear Energy, Science and Technology; U.S. Department of Energy*

Since the last Contractor Information Exchange in May 1996, significant progress has been made in several areas. Three additional nuclear power plants have joined U.S. partners in cooperative work to improve safety. The Armenia Nuclear Power Station has projects under way in fire safety. Two plants in Russia—Bilibino and Beloyarsk—are receiving support in training methods and a simulator.

Several new projects have begun since May. Technology transfer is under way for plants in Russia and Lithuania for key safety equipment, including an emergency power supply, instrument control modules, circuit breakers, and valves. Safety parameter display systems are being developed for 13 reactors in Russia and Ukraine. These systems enable operators to view quickly the status of reactor conditions for controlling plants in the event of an accident. Configuration management systems are being developed for the Novovoronezh and Balakovo plants in Russia and the Zaporizhzhya plant in Ukraine. Such systems provide important information for identifying safe operating boundaries within the plant's current configuration. Plant-specific, in-depth safety assessments are under way for reactors at Ukraine's Zaporizhzhya, South Ukraine, and Khmelnytsky plants and at Russia's Kursk plant. Such safety assessments are necessary for identifying the most significant risks so that limited resources can be applied effectively.

The United States is supporting Russia in eliminating plutonium production at its three remaining production reactors. The U.S. policy goal is to stop Russian plutonium production by 2000. The United States and Russia have determined that it is feasible to convert the cores of the existing reactors to an alternative fuel design that would not produce weapons-grade plutonium. In January 1996, Vice President Gore and Prime Minister Chernomyrdin agreed to support recommendations of the feasibility study and proceed with design and analyses. Core design, analysis, and testing are scheduled to be completed by September 1997.

An in-country presence is critical to coordinating the cooperative safety work. The U.S. Department of Energy saw so much value in the Moscow Adjunct Office that it opened a similar office in Kiev, Ukraine, in February 1997. Alex Sich of the Pacific Northwest National Laboratory staffs that office. His role is to coordinate and help implement U.S. nuclear safety activities in Ukraine, integrate cross-cutting technologies, and communicate U.S. nuclear safety goals and work status with officials and industry representatives in Ukraine. Alex's E-mail address is <[alexsich@carrier.kiev.ua](mailto:alexsich@carrier.kiev.ua)>. When available, Alex's address, phone, and fax numbers will be placed on the Internet web site for the U.S. Department of Energy's international nuclear safety work (<http://insp.pnl.gov:2080>).

The Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology is moving forward with technical projects. This center was established in 1996 in Slavutych, Ukraine, near the Chernobyl nuclear power plant. The United States is supporting the infrastructure development of this scientific and technical center as a focal point for addressing nuclear safety and environmental issues. Last October, a satellite-based telecommunications system was installed to facilitate cooperative work and sharing of data.

The United States is working with Ukraine and other nations in support of activities to resolve safety issues associated with the shelter surrounding the damaged Chernobyl reactor Unit 4. Short-term activities focus on reducing risks inside the shelter caused by high radiation fields and deteriorating conditions. Longer-term activities focus on stabilizing the shelter structure.

An initiative is under way with Ukraine to demonstrate ways to stabilize that country's energy sector. Energy Secretary O'Leary began working more than a year ago to identify opportunities for private sector investment. Such investments support U.S. interests by increasing Ukraine's energy independence, enabling the United States to reduce its economic support over time, and increasing the likelihood of the shutdown of the Chernobyl nuclear power plant by 2000. To date, two pilot energy projects have been identified: a chemical plant and an iron and steel plant. Plans for seeking private investment in these plants are going forward.

In FY 1996, the Government Accounting Office audited the U.S. Department of Energy's work to improve the safety of Soviet-designed nuclear power plants. The U.S. Department of Energy gave its response to the audit report in February 1997. Many of the issues the Government Accounting Office identified arose because of the relatively early timing of the audit and since have been corrected. A key issue was the lack of a definitive strategy for the effort—in other words, how do we see the activities ending, and how do we know the work has accomplished its objectives? A strategy and vision since have been developed, indicating that the work ends in 2003. Funding is dependent on time-phased needs in those years.

Incoming Energy Secretary Federico Peña has been briefed on the U.S. Department of Energy's nuclear safety work. Indications are that international nuclear safety will remain a strong priority. Recently, he has taken a personal interest in meeting with high-ranking nuclear safety officials from Russia and Ukraine who were visiting the United States.

The Gore/Chernomyrdin Commission recently finished its eighth session. Led by U.S. Vice President Gore and Russian Prime Minister Chernomyrdin, the Commission meets regularly to discuss issues of mutual importance. Part of the discussion pertained to the Russian energy sector and nuclear safety. A top priority in the coming years will be the disposition of nuclear materials. The U.S. dual-track approach was discussed, which comprises burning plutonium in reactors and immobilizing it. Another issue for the future is the transition of the Russian nuclear complex. In the area of nuclear safety, the most significant issue was the potential restart of the Kursk reactor Unit 1.

Similar to the Gore/Chernomyrdin Commission, a comparable bilateral commission recently was established with Ukraine. The Energy Working Group of this Commission focuses on strengthening

Ukraine's energy sector. A new nuclear utility in Ukraine, Energoatom (officially known as UkrAtomEnergo), has been formed. This utility potentially could obtain loans from the European Bank for Reconstruction and Development and other international lenders for such projects as the completion of two unfinished reactors at Rivne and Zaporizhzhya. It is unclear at this point what role the utility will have in terms of the Ukraine's nuclear power plants.



## 3.0 Budget Summaries

*Speaker: Dan Giessing; Deputy Associate Director for International Nuclear Safety; Office of Nuclear Energy, Science and Technology; U.S. Department of Energy*

### 3.1 FY 1997 (Current) Budget for Improving the Safety of Soviet-Designed Nuclear Power Plants<sup>(a)</sup>

At the time of the last Contractor Information Exchange in May 1996, the U.S. Department of Energy had requested \$66 million for the FY 1997 budget for this work. The amount Congress appropriated was \$45 million.

Several projects continue from FY 1996. For example, the training programs in Russia and Ukraine have established pilot plant sites; however, participants now are transferring training methods from the pilot plants to the other sites. Other continuing projects of note are safety parameter display systems, in-plant safety analyses, and U.S./Russia nuclear safety centers.

Key new projects under way in FY 1997 include training simulators, equipment reliability database work in Russia and Ukraine, event analysis and reporting, and nondestructive evaluation. In FY 1997, there also is a strong emphasis on plant safety assessments at Ukraine's Zaporizhzhya, Khmelnytsky, and South Ukraine plants and Russia's Kursk, Kola, and Novovoronezh plants. In addition, two new projects with Armenia are planned for FY 1997: an alternate decay heat removal system and an emergency feed-water system. FY 1996 work with Armenia involved fire safety.

The funding needed for these new and continuing projects in FY 1997 totals \$81 million. The U.S. Department of Energy expects to make up the shortfall between the appropriated \$45 million and the needed \$81 million by receiving additional funding from other sources later this year. One source is the U.S. Agency for International Development. Through the Foreign Operations budget, \$35 million was designated specifically for work with Ukraine for safety parameter display systems, safety analysis, training simulators, and plant safety assessments. Another \$6 million was designated through the Foreign Operations budget for work with Armenia.

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(a) The U.S. Department of Energy report, *Improving the Safety of Soviet-Designed Nuclear Power Plants, Status Report*, dated November 1, 1996, contains detailed information about the scope and progress of projects. The reader may wish to refer to this report for more details about projects for which budget and funding information is summarized here. For a copy of the report, contact Nancy Jackson, Pacific Northwest National Laboratory, at P.O. Box 999, K7-74, Richland, Washington 99352. Phone is (509) 372-4679. Fax is (509) 372-4411. E-mail is <na\_jackson@pnl.gov>.

In FY 1994 and 1995, much of the work focused on projects in Russia. This is balanced somewhat by the FY 1997 budget allocation, which contains a substantial portion for Ukraine because of the designated \$35 million from the U.S. Agency for International Development. The other country receiving more funding emphasis this year is Armenia. Armenia restarted one of its reactors in 1995 after it was shut down in early 1989 following an earthquake in December 1988. Government and plant officials have made commitments to work with the United States and other countries to improve safety there.

The U.S. Department of Energy has received an additional \$27 million from the U.S. Agency for International Development for work at Chernobyl. This work is in cooperation with Ukraine and the European Commission to develop a plan for short- and long-term measures to stabilize the deteriorating shelter surrounding the damaged Unit 4 Chernobyl reactor. In addition, several bilateral projects are under way to improve the safety of conditions inside the shelter. These shelter upgrade projects are budgeted at about \$10 million for this fiscal year.

As part of the \$27 million, the State Department has designated \$6 million for replacement or upgrade of the heat plant supporting the Chernobyl reactors. \$1 million is designated for developing deactivation plans for Chernobyl reactor Units 1 and 2. The budget also includes projects at the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology, which continues into FY 1998.

### **3.2 Proposed FY 1998 Budget**

The U.S. Department of Energy has requested \$50 million from Congress for FY 1998 for improving the safety of Soviet-designed nuclear power plants. This work does not include funding specifically designated for Chernobyl projects; potential funding sources for Chernobyl work are under discussion.

The \$50 million represents essentially a continuing level of funding from FY 1997. Most of the funding is for projects that are continuing from previous years. This is partly because the U.S. Department of Energy does not budget the complete funding for continuing projects in the year in which the projects begin. Instead, the amount of money planned to be spent on a continuing project is allotted for each year. This approach optimizes budget management by minimizing the amount of funding carried over to the following year.

Several pilot startup projects are being undertaken in FY 1997. These include projects in configuration management, quality assurance, and instrumentation and control. If Congress approves the requested funding, these projects will be ready for full implementation in FY 1998. Additional work in FY 1998 is planned with countries in Central and Eastern Europe and Armenia.

After the President's budget is submitted, the U.S. Department of Energy can begin discussing the details of its proposed budget with Congress. Two of the most significant questions Congress repeatedly asks are 1) how do we know whether we are meeting our objectives, and 2) how do we know when the program is going to end. This year, the U.S. Department of Energy is in a better position to address those questions because we have developed a robust strategy and vision for the nuclear safety work, including a

phased budget and specific end points for the technical work. As always, it is important to present the work each year in such a way that people understand that the objectives are being achieved and that U.S. interests are being served. In addition, Ambassador Morningstar from the U.S. State Department, the overall coordinator for assistance to the New Independent States, has been very supportive in working with the U.S. Department of Energy to present the work to Congress.

Doug Todd, Battelle's Manager of Government Relations in Washington, D.C., holds meetings with contractors involved with the U.S. Department of Energy's international nuclear safety work every two to four weeks during the legislative season. During these discussions, participants can learn about the status of legislation impacting the work, as well as keep abreast of the budget process. Contractors wishing to participate in these meetings should contact Doug Todd by phone at (202) 646-7860, by fax at (202) 646-5271, or by e-mail at <toddmd@battelle.org>.



## 4.0 State Department Perspectives on International Nuclear Safety

*Speaker: Carol Kessler; Senior Coordinator; Nuclear Reactor Safety; U.S. Department of State*

The U.S. government assistance program for improving the safety of Soviet-designed reactors is 5 years old. We have not been able to accomplish as much as we had hoped when the work began in 1992. A primary reason has been the delay in economic and energy sector reform. U.S. assistance is directed at several fronts, including supporting economic and energy sector reforms. Energy sector reform is aimed at building a more attractive energy sector for domestic and international investment. Nuclear safety must be viewed in the broader context of these overall reform programs as these reforms will enable revenue streams needed to pay for safety.

U.S. support is integrated with other multilateral assistance to ensure efficient and effective safety assistance with the limited resources available. The State Department's Ambassador Morningstar, the overall coordinator for assistance to the New Independent States, has been instrumental in securing congressional support for U.S. safety assistance.

It is important to recognize that U.S.-funded safety work is not supporting the continued operation of unsafe reactors. Certain Soviet-designed reactor types have distinct safety problems. The RBMK reactor is susceptible to power instabilities and lacks a modern containment system to prevent release of radiation to the environment. The VVER-440/230 reactor has no containment system and no emergency core-cooling system. A safety analysis report recently was completed for Lithuania's RBMK reactors. This report brings to light additional, cross-cutting problems inherent in the RBMK reactor. In contrast, the VVER-440/213 and VVER-1000 models have the potential for safer long-term operation.

Making the distinction between the two groups of older and newer reactors is important because the focus of safety work for each is different. For the RBMK and VVER-440/230 reactor types, the work is aimed primarily at upgrading inadequate safety systems to reduce urgent risks until the reactors can be shut down. For the VVER-440/312 and VVER-1000 models, work focuses more on providing modern safety technologies that can be sustained over time by the host countries as these reactors continue to operate.

The United States is interested in seeing strong safety cultures established in the countries where Soviet-designed reactors operate. In addition, U.S. involvement is based on the premise that the support eventually will transition from federal assistance to the commercial sector. Good examples of successes are in Hungary and the Czech Republic, where nuclear safety cultures are being established that have the potential for becoming commercially viable.

## **4.1 G-7 Nuclear Safety Working Group**

The group of industrialized nations called G-7 established the G-7 Nuclear Safety Working Group in 1992. The nations that make up the G-7 are Canada, France, Germany, Great Britain, Italy, Japan, and the United States. The G-7 also includes the European Commission. G-7 work is coordinated with and complemented by that of the International Atomic Energy Agency, the Organization for Economic Cooperation and Development, the Nuclear Energy Agency, the European Bank for Reconstruction and Development, and the World Bank. The goal of the G-7 Nuclear Safety Working Group is for the recipient countries to establish self-sustaining safety practices that meet international standards. Meeting this goal requires transferring technologies, strengthening the regulatory organizations, improving operational safety, and establishing a sustainable safety culture. The United States is a leader among the G-7 nations in providing assistance to upgrade the safety of Soviet-designed reactors. The United States is the largest single G-7 Nuclear Safety Working Group.

The G-7 activities currently focus strongly on Russia and Ukraine. Lithuania is also of concern because of its large RBMK reactors for which an in-depth safety analysis was just completed. Bulgaria has a new government in place that is expected to encourage the growth of democracy, which should strengthen our nuclear safety work with them. Armenia has been a cooperative partner with the G-7 nations and the rest of the international community. Armenia's two nuclear power reactors were shut down after a major earthquake in December 1988. In 1995, the country restarted reactor Unit 2, which provides 40% of the nation's electricity. However, the Armenian government recognizes that the reactor does not meet international safety standards and has agreed to close it by 2004. The World Bank and European Bank for Reconstruction and Development are working with Armenia on projects for replacement power for that country.

G-7 activities with Russia have been building on the momentum achieved by the Moscow Nuclear Safety and Security Summit, a presidential-level event in April 1996. At that summit, world leaders held discussions on the importance of working together to improve the safety of Soviet-designed reactors. A key area of focus evolving from the summit was that nuclear safety be given the highest priority rather than the production of electricity as was the case in much of the Soviet Union.

## **4.2 Russia**

The United States is supporting an important agreement between the European Bank for Reconstruction and Development and the Russian Federation through a Nuclear Safety Account. This grant agreement provides \$90 million in assistance to Russia's Leningrad, Kola, and Novovoronezh plants to support nuclear safety improvement. In return, Russia has committed to three activities in support of a sustainable nuclear safety strategy. One is conducting in-depth safety assessments that can provide the basis for a new licensing regime. The second activity is to use the results of the safety assessments to determine whether nuclear power plants would qualify for a long-term operating license or must prepare for shutdown. The third commitment by Russia is to develop strategies for strengthening its energy sector to make it more

commercially viable and able to provide revenues needed to secure safer reactor operations. A stronger energy sector provides a foundation for future shutdown of existing high-risk nuclear power plants by creating additional, stable sources of electricity as replacement power.

The European Bank for Reconstruction and Development has proposed to work with Russia to develop two investment strategies corresponding to two areas of Russia. One is the Northwest region, covering the Kola and Leningrad reactors. The other would be for the Central region, covering Kursk and Novovoronezh.

Russia is interested in restarting Kursk Unit 1, an early-generation RBMK reactor. The United States does not support its restart. The United States is asking Russia to conduct a safety assessment before restarting the reactor.

Russia is moving forward, but has not yet passed domestic nuclear liability legislation. This legislation will offer the commercial provider of safety upgrades protection from liability for nuclear-related malfunctions or accidents. Such laws will facilitate provision of advanced safety technology to Russia. The Russian government must now take the step of ratifying the Vienna convention on liability. Ratification is expected in the next 6 months.

Adherence to international nuclear liability conventions is needed to help ensure the effective commercial trade in nuclear equipment and technology for nuclear programs. A new liability convention is being negotiated to allow the United States to enter into treaty relations on nuclear liability with Russia and other countries. International experts have nearly reached agreement on a text for this convention. In the next 3 to 6 months, we hope the text will be completed. At that time, the International Atomic Energy Agency will open a diplomatic conference to formally negotiate this treaty. The timing of this depends on the timely approval of the governments of the countries involved.

Strengthening the energy sector in the New Independent States is a primary goal of the G-7 Nuclear Safety Working Group. The United States is interested in stimulating reforms in banking and taxation to encourage private investment. Russia and the United States conducted a study last year to look at proposed energy sector initiatives, including those for the nuclear sector for domestic and international investment. Implementation of proposed initiatives will not be possible without reforms that allow Russia to pay back loans from lenders. The Northwest region of Russia is of particular interest for potential energy sector investment. Because of its connections and proximity to Europe, the power plants in Russia's Northwest region will likely have a greater ability to pay back loans in hard currency sooner than other regions in Russia.

Another issue for the G-7 is safe management of nuclear waste. The International Atomic Energy Agency is negotiating an international convention on safe management of waste and spent nuclear fuel. Rather than being prescriptive, the convention sets broad goals for safe management of nuclear waste. Key issues under negotiation are whether spent fuel is defined as waste and how to handle military waste.

Russia lacks resources to store and treat liquid radioactive waste on a broad scale. The United States is encouraging Russia to adhere to the London Dumping Convention, the protocol that prohibits ocean disposal of nuclear waste. In support of this goal, the United States and Norway are helping Russia build a liquid-waste treatment facility in Murmansk. The Japanese are doing the same thing for Far Eastern Russia.

### 4.3 Ukraine

The G-7 group's work with Ukraine has focused on the implementation of a Memorandum of Understanding signed with Ukraine in 1995. In this memorandum, Ukraine agreed to shut down the Chernobyl nuclear power plant by 2000 in exchange for international grant and loan support to help with safety and other problems at Chernobyl and to strengthen Ukraine's power sector. A key aspect of this support is restructuring of the Ukrainian power sector, which involves developing an electricity market and a financially viable power utility in Ukraine. Efforts directed toward these goals have been somewhat successful. Ukraine has established a fledgling electricity market. Thermal power plants are bidding to provide power. The goal is for all electricity to be offered on a competitive basis, through the electricity market. A key to making this approach successful is that customers, especially industry, must pay for their electricity on time and in hard currency. Currently, because of Ukraine's fragile economic situation, this is rare. The Ukrainian government subsidizes much of the electricity provided.

Another part of the Memorandum of Understanding for Chernobyl shutdown concerns energy sector investment. For Ukraine, the completion of Rivne Unit 4 and Khmelnytsky Unit 2 reactors is a top priority. The reactors are partially completed. Ukraine's Minister Kostenko told the G-7 that the Chernobyl nuclear power plant will not close unless Ukraine receives funding to complete the Rivne Unit 4 and Khmelnytsky Unit 2 reactors for replacement power. The G-7 position is that any consideration of investment in the plants must be proven as part of a least-cost strategy and must be financially and environmentally viable.

The European Bank for Reconstruction and Development contracted an independent least-cost study of the two unfinished reactors and established a panel of international experts to study the issue. The panel concluded that completion of the two plants was not part of the lowest-cost investment alternative for Ukraine's power sector. This conclusion was based on two key factors. First, Ukraine has excess generating capacity from other sources, especially thermal plants, that is not being used because the country cannot afford to pay for the necessary fuel in the current economic climate. Second, a \$1 billion loan would be necessary for Ukraine to complete construction of both reactors. The nuclear utility of Ukraine must be able to pay back that loan, which is unlikely in Ukraine's currently unstable economic and political environment. Instead, the panel recommended that the European Bank for Reconstruction and Development might consider smaller, less risky, more diverse investments that would have a broader impact on strengthening Ukraine's overall energy sector.

The European Union is funding a feasibility study on the costs of completing the unfinished reactors at Rivne and Khmelnytsky. It is difficult to identify the degree of completion at the two reactors; more information from Ukraine, as well as on-site inspections, are needed.

Other potential energy sector projects are being considered or are under way in energy transmission and in thermal and hydroelectric plant improvements and energy efficiency.

Over the last 9 months in Ukraine, the energy sector has undergone significant reform. Ukraine is planning to consolidate its electricity sector into seven utilities. The nuclear utility structure still is evolving. It will cover the nuclear plants in Ukraine except Chornobyl.

The United States' support for the Chornobyl Memorandum of Understanding focuses on several efforts:

- supporting the construction of decommissioning facilities needed to shut down Chornobyl by 2000 through a grant to the Nuclear Safety Account of the European Bank for Reconstruction and Development
- finding a viable solution for repairing the deteriorating shelter surrounding Chornobyl Unit 4 and managing the waste and monitoring activities inside
- providing near-term safety upgrades for the operating Chornobyl Unit 3. In addition, the European Bank for Reconstruction and Development, through the Nuclear Safety Account, plans to fund additional safety improvement projects.
- addressing the social impacts of Chornobyl shutdown.

The issue of social impacts is an important one for Ukraine. The community of Slavutych is economically dependent on Chornobyl. Without replacement jobs, closing Chornobyl would leave the highly specialized work force idle and shut down an entire community. Chornobyl personnel are highly skilled and well-trained; many have academic backgrounds at the master's or doctoral levels. Their skills and experience make them ideal candidates for future work associated with shelter repair and reactor decommissioning. The Ukrainians recently developed a worker profile, showing the numbers and types of workers expected at various time periods through Chornobyl closure. This profile will be a valuable tool in helping the employees find other business opportunities.

The recently established Chornobyl Center for Nuclear Safety, Radioactive Waste and Radioecology is designed in part to address these socioeconomic needs while providing Ukraine with a unique technical resource. Ukraine established the Center in Slavutych in 1996 with the support of the United States. U.S. specialists are working with Chornobyl Center and plant representatives to transition existing Chornobyl workers to the Center. Once appropriately trained, the workers will conduct

nuclear safety, decommissioning, and environmental activities for Chernobyl and other nuclear power plants in Ukraine. The United States and other countries are providing support for specific technical projects.

Another way to help the Slavutych community become more economically self-sustaining is to develop business opportunities there. There will be a conference in Washington, D.C., later in 1997 to promote such opportunities. One plan being considered is to employ workers at a factory that would manufacture equipment for energy efficiency.

The United States is holding the G-7 summit the third week in June in Denver, Colorado. One focus is nuclear safety. If we succeed to define a Ukraine/G-7 approved project for stabilizing the Chernobyl Unit 4 shelter, we hope to use the summit to announce G-7 financial support for the project. At issue is how to deal with the large masses of highly radioactive fuel that melted and hardened during the 1986 accident. Chernobyl and Ukrainian nuclear officials originally wanted to move these fuel-containing masses, as they are called, out of the shelter to a temporary disposal site, to reduce the risk to workers who monitor conditions inside the shelter and to demonstrate progress in cleanup. G-7 nations, including the United States, were concerned about the potential radiological hazards associated with an activity of such magnitude. In a recent workshop, the G-7 and Ukraine agreed to develop a phased shelter implementation plan. This plan will contain decision points regarding timing and extent of shelter stabilization and new shelter development, and development of a strategy for eventual long-term removal of the fuel-containing masses. The plan will identify studies and engineering designs needed to provide the basis for the decisions.

## 5.0 Labor Rates for Former Soviet Union Countries

*Speaker: Jeff Ace; Pacific Northwest National Laboratory*

*Note: Pacific Northwest National Laboratory manages all the contracting for the U.S. Department of Energy's work to improve the safety of Soviet-designed nuclear power plants.*

In the implementation of cooperative nuclear safety projects, the U.S. Department of Energy funds technical services provided by staff in the former Soviet countries. Often, these services are in the form of a subcontract with Pacific Northwest National Laboratory or a U.S. commercial contractor. Thus, it is important to determine a fair price for labor in former Soviet countries. This discussion focuses on determining fair prices for labor in Russia and Ukraine, where most of the contracting occurs.

Under direction by the U.S. Department of Energy, Pacific Northwest National Laboratory began initiating contracting activities for the Soviet-designed reactor safety work a little over 2 years ago. At that time, the Laboratory based the contract labor rates on guidelines issued by the Departments of State and Energy, associated with other programs, concerning the price of labor in the former Soviet Union. At that time, the benchmark was between \$400.00 and \$600.00 per person-month, fully burdened.

It quickly became apparent that it was going to be difficult to implement that range for the U.S. Department of Energy's nuclear safety work because of our different objectives and because of the different host country organizations and institutions with whom we do business. Therefore, the Laboratory undertook two activities to determine a fair price for labor in Russia and Ukraine. One was to commission a salary survey by Price-Waterhouse in Moscow. The other was to begin subscribing to an Ernst & Young salary survey, the results of which are used by many Western companies doing business in Russia and Ukraine. The Ernst & Young survey addresses various industries and contains specific labor categories, with salary ranges for each. In addition, the Laboratory has continued to gather information from those who participate in the U.S. Department of Energy's international nuclear safety work, capturing new data as much as possible.

Pacific Northwest National Laboratory receives a wide range of proposed labor rates submitted by contractors. For accountability, the labor rates negotiated must be based on salary surveys and other objective data.

One trend in contracting with former Soviet countries is the increasing use of commercial or quasi-commercial companies as opposed to nuclear power plants or research and technical institutes. Thus, the proposed labor rates are beginning to include overhead rates and profit factors. Some of these overhead rates have been several times higher than the actual labor costs, yet they are virtually impossible to quantify and verify to anything close to Western standards.

Pacific Northwest National Laboratory received the latest Ernst & Young salary survey in early February. At the time of the February 19 meeting, the salary survey was still being analyzed by staff in Richland, Washington. However, informal correspondence with Ernst & Young about the survey indicated that very little had changed in labor rates in Russia and Ukraine from previous reports. These salaries range from \$600 to \$800 per person-month for a non-bilingual secretary to about \$2474 per person-month for what is called the General Director. These labor categories are not precise to our work but they can be translated generally to our labor categories.

Those are salaries paid to the individual. In Russia and Ukraine, it is difficult to determine how to define the term "fully burdened." At the host country nuclear power plants, the Laboratory has taken the approach that the United States will pay the labor rates previously mentioned, without any additional burdening. In doing so, the Laboratory assumes that any additional overheads or infrastructure rates are contributed by the host country as part of the cooperative nuclear safety work.

The Laboratory is ordering specific, independent information from a Russian organization that is a spin-off of the Ernst & Young company for salaries targeted toward Kiev and St. Petersburg. In addition, the same company will provide a report on inflation and the cost-of-living index for Moscow.

In the meantime, the Laboratory continues to negotiate specific elements of cost proposals, conveying expectations of what the companies must provide to justify overheads and other labor rate factors. In this way, the Laboratory negotiates the fixed price or bottom line for each job to be done. The negotiated labor rates are consistent with the information collected from the salary surveys to date.

Having a unified team contributes to successful contract negotiations. The unified team consists of program office support, project manager support, and any U.S. laboratories or contractors involved. It is important to ensure that no U.S. individual or organization become advocates for specific Russian or Ukrainian contractors.

The salary surveys are copyrighted. Contractors working frequently in Russia and Ukraine may wish to consider subscribing to the salary surveys as a business tool. For information about subscribing, contact Jeff Ace, Pacific Northwest National Laboratory, at telephone (509) 375-2640, fax (509) 372-4411, or e-mail: <jk\_ace@pnl.gov>.

## 6.0 Technology Transfer

*Speaker: Rich Denning; Pacific Northwest National Laboratory*

The term *technology transfer* refers not just to the delivery of equipment but to the passing on of knowledge, processes, and methods. In work to improve the safety of Soviet-designed nuclear power plants, the goals of technology transfer are to

- Facilitate the incorporation of pilot-plant upgrades at all plants.
- Sustain system upgrades.
- Help reestablish host-country infrastructure for the supply or manufacture of nuclear safety system components.
- Strengthen the regulatory organizations in the host countries. An effective regulatory organization is a powerful tool in ensuring that the improvements at the pilot plants are extended to other plants in the same country. The regulator can enforce nuclear safety standards and ensure that all the plants are upgraded to meet those standards.

The Strategy Document in Appendix E identifies the vision, goals, and end points for the U.S. Department of Energy's cooperative nuclear safety work. Technology transfer has a major role in the rationale underlying this vision in terms of bringing this work to a conclusion. It is clear that U.S. financial resources, even when augmented by those of other countries, are insufficient to improve safety at all Soviet-designed nuclear power plants to a level consistent with international standards. Therefore, in many areas we have taken a pilot plant approach, in which the United States provides hardware to a few of the plants in conjunction with complementary technology transfer. In this way, the pilot plants receive the most urgently needed equipment and tools to reduce immediate risks. At the same time, plant personnel, government organizations, and private companies in the host countries acquire the skills and capabilities to sustain these system upgrades at the pilot plants and extend these upgrades to other plants.

At the May 1996 Contractor Information Exchange meeting, an ad hoc working group was established to look at ways to improve technology transfer. That group developed a "white paper" on technology transfer mechanisms, from least to most structured approaches:

- information exchange
- joint project
- personnel exchange
- capability transfer

- licensing
- joint venture.

At the quarterly program meeting in July 1996, the technology integrators were asked to evaluate technology transfer in their specific areas, using the white paper as a stimulus for that review. The technology integrators then identified specific areas requiring enhancement to optimize technology transfer.

The result of that review is summarized in a revised draft white paper, *Enhancing Technology Transfer in DOE's International Reactor Safety Projects*. The paper, included in Appendix D of this report, should be viewed as a status of, rather than a program plan for, technology transfer.

Most of the other technology areas, such as training, embody technology transfer as a fundamental aspect of the approach to the work. Nevertheless, the area of systems upgrades is worthy of particular scrutiny. Work in this area is aimed at providing improved equipment and capabilities for fire protection, radiation confinement, emergency power and water, and other key safety systems. However, it is particularly important to provide not just hardware, but the capabilities and technology to enable the host country representatives to design, manufacture, and maintain safety systems over the long term.

## 6.1 Technology Transfer Initiatives

Technology transfer initiatives are highlighted here for four specific areas: direct-current (dc) power supplies, instrumentation and control modules, circuit breakers, and valves.

Direct-current power supply systems provide reliable power for emergency shutdown at nuclear power plants. Burns & Roe has provided upgrades to dc power supplies for two Russian nuclear power plants: Kola Units 1 and 2 and Kursk Unit 2. Burns & Roe also will be supplying an improved dc power supply at Lithuania's Ignalina nuclear power plant. This work involves providing support to the plants in separating safety and nonsafety electrical loads and in sizing and designing dc power supply systems. A paper presented at the 1996 Nuclear Science Symposium and Medical Imaging Conference of the IEEE, "*Safety System Augmentation at Russian Nuclear Power Plants*," describes this work (Appendix D).

The plants at Ignalina fit into the first step of technology transfer. If the appropriate arrangements can be made with the American battery manufacturer, a Russian manufacturer will be brought to the United States while the Ignalina batteries are being produced, to observe the manufacturing process.

In June 1997, U.S. participants will host a dc power supply workshop in Moscow. Personnel from Russian nuclear power plants will be invited. The purposes of the meeting are to 1) share information about the value and process of upgrading dc power supplies and 2) determine the status of dc power supply systems at nuclear power plants to better understand the support required. Burns & Roe specialists will lead the workshop, using the work done at Kola and Kursk as a foundation.

To continue upgrading and maintaining dc power supplies after U.S. support ends, the host countries must have the capabilities to design, manufacture, and maintain associated equipment. Burns & Roe specialists are working with dc power supply manufacturers in Russia and the United States to determine the best methods for transferring this technology to Russia.

Aging instruments for process control at the Ignalina plant are failing at increasing rates and cannot be relied on to perform their safety functions. At Ignalina, new instrument modules were not available for replacement; operators were forced to scavenge parts from previously failed instrument systems. The U.S.-based company Scientech will provide the first set of 100 replacement modules, which will meet modern technical requirements and have the same form, fit, and function as those currently in place. To develop Lithuania's capabilities, Scientech will transfer the technology to a manufacturing company in Lithuania. That company, EMC, will manufacture 200 more modules for Ignalina. With that manufacturing capability in place, the Lithuanian company can serve as a future resource for Ignalina and perhaps for other nuclear power plants as well. In March 1997, U.S. specialists will train EMC staff in quality assurance so that they can ensure that the modules provided by EMC meet operational requirements.

The Russian nuclear utility organization Rosenergoatom surveyed Russian nuclear plant personnel in 1996 to identify key safety problems. Several plants identified a serious problem with 6-kV and 400-V circuit breakers. Not only did they not operate as designed, but they also caused fires on occasion. In January 1997, U.S. specialists from Bechtel met with companies in the Moscow area to discuss ways to develop an in-country capability for circuit breaker manufacturing for Russian plants. In the next phase of this activity, Rosenergoatom will develop performance specifications for 6-kV and 400-V breakers. Bechtel will then hold discussions with Western circuit breaker manufacturers to determine their interest in participating in a transfer of technology.

Valves perform a variety of safety functions in nuclear plants including pressure relief, actuation of emergency core cooling flow, and confinement isolation. Burns & Roe has the lead on a technology transfer activity aimed at improved valve monitoring and performance at host country nuclear power plants. To begin, Rosenergoatom is collecting data on valve performance to determine those areas in which technology transfer might be effective in improving plant safety.



## 7.0 Strategy for the U.S. Department of Energy's Cooperative Nuclear Safety Work

*Speaker: Richard Reister; Office of International Nuclear Safety; Office of Nuclear Energy, Science and Technology; U.S. Department of Energy*

### 7.1 Establishing a Mission, Vision, and End Points

The Strategy Document<sup>(a)</sup> was developed for the U.S. Department of Energy's international nuclear safety work to define where we are going, when the work will be completed, and what we will have achieved when we are finished.

The mission is two-fold:

- Reduce the risks at Soviet-designed nuclear power plants, without discouraging the continued operation of the older plants (RBMKs and VVER-440/230s).
- Implement self-sustaining nuclear safety improvements. Our job is not to bring all the plants up to international safety standards, but to put the host countries on a path where they can continue to do that themselves.

The vision, within a decade, is that

- Soviet-designed plants are operated and regulated using internationally accepted practices.
- Safety is appropriately placed at the highest level of importance in design, operation, and regulation.
- The infrastructures, expertise, and resources exist in the host countries to enable active participation in international nuclear safety work.

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(a) The Strategy Document discussed here is included as Appendix E of this report. The report reflects comments from reviews by the U.S. Department of Energy, U.S. Department of State, U.S. Agency for International Development, U.S. Nuclear Regulatory Commission, U.S. General Accounting Office, and the integrators for each of the key technology areas.

## 7.2 Relationship to Other Key Documents

To put the Strategy Document in context, it helps to think of its relationship to other key documents. The Strategy Document is at the highest level, giving a broad view with an eye toward the future, especially completion of the work. One level beneath the Strategy Document is the Program Plan, which gives details about objectives, projects, schedules, and estimated funding required. Status reports, the most recent of which was issued early this year, describe progress and achievements over time. The Performance Measurement report, which the U.S. Department of Energy will issue annually, measures the effectiveness of the work. That report looks at how well we are achieving what we planned and how much impact the work is having.<sup>(a)</sup>

Ideally, the results of the Performance Measurement report feed back into the Program Plan. The intent is to step back and take an objective view of the work, to determine whether mid-course corrections are needed. It is important to be willing to make changes based on the results of performance measurement.

## 7.3 Selecting Projects

Projects must meet three main criteria to achieve the mission and vision: impact on safety, cost-effectiveness, and host country commitment and sustainability.

Impact on safety is the most important criterion. To measure impact on safety, the U.S. Department of Energy relies heavily on independent reviews. Such reviews include those conducted by the International Atomic Energy Agency to establish a prioritized list of key safety deficiencies at Soviet-designed reactors. More recently, the U.S. Department of Energy also has measured safety impact using safety analyses and risk assessments such as one done recently for Lithuania's Ignalina nuclear power plant. Such assessments reveal which safety improvements have the greatest impact on safety. Another measurement of impacts is how many plants are affected by the improvement, how far-reaching it is. Technology transfer activities are necessary for achieving this broader effect.

Cost-effectiveness is a determination of the amount of benefit for cost incurred. This kind of evaluation must be done with a broad view of all the projects and how they leverage off one another. For example, a relatively high-cost project may nevertheless have a high cost-benefit ratio because it affects safety at many other plants.

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(a) To obtain copies of these documents, contact Nancy Jackson, Pacific Northwest National Laboratory, at: P.O. Box 999, K7-74, Richland, Washington 99352. Phone is (509) 372-4679. Fax is (509) 372-4411. E-mail is <na\_jackson@pnl.gov>.

Host country commitment comprises two factors: 1) the amount of money and resources the host country is willing to commit to a particular project, and 2) its interest in the project, specifically, whether the extent to which the host country feels the project meets an important need at the country's nuclear power plants.

Sustainability must be addressed in each project by specifying how knowledge, methods, and capabilities will be transferred to the host countries to build a lasting safety culture and infrastructure.

The technologies transferred usually are those that are in broad use in the international nuclear community, rather than specialized, proprietary technologies that companies are marketing for profit. Sometimes a joint venture or other cooperative business arrangement is the best approach, where the host countries manufacture the product. In this way, the U.S. company does not incur costs of shipping a U.S.-manufactured product to the host countries.

## 7.4 Strategy for Implementing Projects

Most of the projects rely on a pilot plant approach, where the technology first is demonstrated at a particular plant and then extended to additional plants. Another key part of project implementation is involvement by the regulatory organizations in the host countries. For projects to be successful and sustainable, host country regulators must take a strong, ongoing oversight role.

## 7.5 Technical Areas and End Points

The work is grouped under six key technical areas, which are described below. Specific end points, or desired conditions at the completion of U.S. work, are identified for each area.

- **Operational safety** focuses on improving management methods and procedures. One end point is that the basic elements of operational safety are implemented at pilot plants by providing training, technology, methodology, and equipment. Another end point is that the utility organizations and regulators are provided the capability to develop guidelines and criteria to enable them to transfer the basic operational safety practices to the other plants in each host country.
- **Training** includes operator training on simulators as well as the use of the Systematic Approach to Training. One end point is the development of pilot training centers and training courses with the subsequent transfer of training methods to other plants. Another end point is that training simulators are available for use at all the plant sites and staff are knowledgeable in using them.
- **Maintenance** involves maintaining safety-related equipment to ensure its proper operation. One end point is that pilot plants have the training, technology, and equipment to implement an effective maintenance program. Another end point is that utility and regulatory organizations have developed guidelines and criteria to ensure the transfer of effective maintenance practices to the other plants.

- **Safety systems** focus on alleviating major deficiencies through system upgrades. The end points are for all plants to have corrected vital safety system deficiencies, for pilot plants to have performed a detailed safe shutdown analysis for fire hazards, and for technology to be transferred to sustain appropriate system upgrades at all plants.
- **Safety evaluations** provide a safety basis for making sound decisions about reactor operations. The end points are for selected plants to complete in-depth safety evaluations and for host country organizations to have a sustainable infrastructure to perform internally accepted in-depth safety evaluations.
- **Legal and regulatory capabilities** encourage strong, independent legal and regulatory organizations in countries where Soviet-designed reactors operate. The end points are for regulators to have the necessary tools and information to perform regulatory oversight of U.S.-sponsored nuclear safety projects, for key policy personnel to have been advised of the benefits of subscribing to nuclear safety treaties and laws, and for host country organizations to have received training on safety and regulatory requirements to operate large research reactors and fuel-cycle facilities.

The end points were developed with an eye toward balancing the need to reduce significant risks without encouraging the extension of reactor lifetimes. Thus, the older reactors, which have safety deficiencies inherent in their design, receive more safety upgrades to prevent accidents. Other technology areas, such as training and safety parameter display systems, are applicable across all reactor designs. However, none of the safety projects extends the plants' life-limiting components, such as the pressure tube interface with graphite material in the RBMK reactor core. In addition, the U.S. contribution to the safety work is a fraction of the resources the host country governments themselves apply to continue operating the reactors. Thus, the comparatively small U.S. contribution of safety support is not the basis for the decision by the host country governments to continue operating the plants. The host country representatives often have stated that the plants must continue to operate to provide urgently needed heat and electricity, as well as jobs, for surrounding communities.

## 7.6 Measuring Performance

Performance is measured in two ways. One is the traditional project management approach of setting and achieving milestones for accomplishing key tasks. In this way, progress is measured by identifying the milestones completed. However, progress is only a partial measurement because it does not indicate the effect of the work. Therefore, a second measurement is necessary, which involves measuring the effectiveness of the work. For each of the six major technical areas, one or more end points have been set, as described in the previous section, "Technical Areas and End Points." The Strategy Document in Appendix E of this report provides more detail about the goals, end points, and corresponding rationale for each technical area.

Effectiveness is measured by determining proximity to the goal in each technical area. These measurements will be determined at least once per year and documented in an annual Performance Measurement Report.

## 8.0 Addressing Safety Issues at Chornobyl: An Overview

*Speaker: Laurin Dodd; Manager; International Nuclear Safety Program Office; Pacific Northwest National Laboratory*

U.S. involvement at Chornobyl began formally with the December 1995 signing of a memorandum of understanding between Ukraine and the G-7 countries. In that memorandum, Ukraine agreed to shut down all its Chornobyl reactors by 2000. The G-7 agreed to provide \$2.3 billion for efforts to

- help remediate current risks at Chornobyl nuclear power plant
- support Ukraine's move toward energy efficiency
- help alleviate socioeconomic impacts of Chornobyl's closure.

U.S. Department of Energy's activities under way at Chornobyl are helping to fulfill the U.S. commitments based on that signing.

However, U.S. efforts there actually began months before the agreement with Ukraine was signed. In 1992, the G-7 had met and agreed to collaborate with Newly Independent States of the former Soviet Union to reduce risks at certain Soviet-designed reactors. The U.S. Department of Energy subsequently began working with various host countries to improve the safety of their Soviet-designed reactors. As part of that endeavor, representatives of the U.S. Department of Energy met in June 1995 with Chornobyl plant management to discuss ways in which they might work together to enhance safety at Chornobyl.

At first, the American delegation was met with cynicism tinged with suspicion. After all, nine years already had passed since the 1986 Chornobyl disaster—and no one in the international community yet had even *offered*, much less actually *done* anything, to help. The United States, represented by the U.S. Department of Energy, the U.S. Department of State, and the U.S. Agency for International Development, ultimately convinced the Ukrainians that the Americans were serious. Initial talks soon led to formal agreements, and several safety-enhancing efforts were started at the Chornobyl plant itself.

Now, a year and a half later, much progress has been made in both safety-related enhancements and relationships with the people of Chornobyl. U.S. Department of Energy's efforts there now are under way in four primary areas:

- remediating safety risks at Chornobyl Unit 3 while it continues to operate
- cooperating with other nations to address and resolve safety issues at Chornobyl Unit 4 (the Shelter or Ukrytie)

- planning with Chernobyl staff for plant decontamination and decommissioning
- working with Ukraine to develop the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology.

This work at Chernobyl is full of challenges. Perhaps one of the most overarching is the socioeconomic impacts of total plant closure.

Slavutych, about 65 kilometers (40 miles) east of the plant, was completed in 1988 to provide housing and services for plant operating personnel. It replaces the town of Prypiyat, abandoned immediately after the Unit 4 accident because of radioactive contamination. Slavutych and the 27,000 people who live there depend entirely upon the Chernobyl plant for their economic well-being; the town has no other major business. Furthermore, despite their overall high level of education, Slavutych residents remain relatively immobile and isolated from the rest of the nation and the world. In the absence of alternative employment opportunities, ultimate closure of Chernobyl's reactors guarantees adverse impacts on the local economy.

## 8.1 Fire Safety Upgrades at Chernobyl Nuclear Power Plant

*Speaker: Mike Archdeacon; Bechtel National, Inc.*

Bechtel has been providing fire protection upgrades for the host countries as part of the U.S. Department of Energy's cooperative nuclear safety work since 1995. This discussion focuses on fire protection upgrades under way at the Chernobyl plant. The Chernobyl plant has four reactor units, but only Unit 3 is currently producing power. Unit 1 was shut down in November 1996. Unit 2 was closed after a turbine hall fire in 1991. Unit 4 was the site of the tragic accident in 1986.

To determine what fire protection components the plant requires, Bechtel met with plant staff and management. Then, in conjunction with the U.S. Department of Energy and Pacific Northwest National Laboratory, the participants reached agreement on specific projects that meet the selection criteria. Fire protection measures for Chernobyl Unit 3 include the following:

- fire doors
- fire detection systems
- penetration sealant materials
- fire-retardant cable coating materials
- floor coating materials to replace the existing plastic floor sheeting material
- fire protective coating materials for structural steel in the turbine hall
- fire brigade support.

Each of these items is discussed in more detail here.

Chornobyl, like many older Soviet-designed nuclear power plants, has fire doors made of wood. Bechtel and Pacific Northwest National Laboratory are working with a company in Kiev to manufacture fire doors that are qualified to the International Standards Organization (ISO) standards. The contract for this work also includes the design and installation of the doors. Two-hundred-fifty fire doors are scheduled to be delivered and installed later this year.

Existing smoke and heat detectors at Chornobyl often give spurious signals and are unreliable. Therefore, modern fire detection systems were given a high priority. Bechtel has identified two U.S. companies that are certified to supply fire detection components to the Ukrainian nuclear industry. Specifically, the certification meets new regulations imposed by Ukraine on all materials since April 1996. Sample equipment was sent to the Chornobyl plant for review. The plant is working with its design agency to begin the design process.

Many penetrations at the Chornobyl plant either need replacement or were never properly sealed during the construction phase. The plant has defined the quantities of material required to seal these penetrations and the schedule for the deliveries. Plant personnel have asked that material be delivered approximately every six months, which gives them time to apply it incrementally before the shelf life expires on any one batch. Bechtel has selected a U.S. supplier that will provide materials and will train staff to apply them to seal penetration openings. The first shipment has arrived; subsequent deliveries will occur every six months through September 1998.

Chornobyl was the first plant to ask about fire protective coating materials for structural steel roof trusses. Chornobyl staff want to avoid an accident at Unit 3 such as the one that occurred in Unit 2 in 1991, in which the roof caved in after 15 minutes when the turbine caught fire. Because no U.S. supplier could be found that was qualified to the Ukrainian standards to produce this material, Bechtel sought a certified German manufacturer whose coating already has been applied to structural steel at some Russian nuclear power plants. Negotiations are under way with a Kiev contractor to supply and install the material.

The operating deck levels of the turbine halls in many of the Soviet-designed nuclear power plants are covered with a very thick plastic sheet material to allow simplicity of decontamination. Bechtel now is working with a U.S. supplier to certify its product for use in Russian nuclear power plants. Ukrainian representatives are witnessing the testing program for this material in Russia. Eventually, Bechtel hopes to have the Ukrainian authorities evaluate the results of the Russian tests to allow use of the material in Ukrainian nuclear power plants.

To upgrade the plant fire brigade, Bechtel is supplying modern fire suits and adjustable hose stream nozzles. Germany already has supplied new breathing apparatus equipment, and Ukraine has supplied new radio equipment for communications during fire emergencies.

In addition to the equipment and materials described here, it is important for the Ukrainians to acquire the capability to identify and evaluate systematically potential fire hazards at their plants. Bechtel and Burns & Roe, working with the U.S. Department of Energy, Pacific Northwest National Laboratory, Brookhaven National laboratory, and other U.S. industry experts, have developed a fire hazards

methodology document. This document, *Reactor Core Protection Evaluation Methodology for Fires at Soviet-Designed Nuclear Power Plants*<sup>(a)</sup>, is designed to enable plant personnel to assess fire hazards and identify the most important and cost-effective changes in procedures and equipment. Brookhaven National Laboratory is providing training for plant representatives, including Chernobyl, to use this methodology to identify and rank fire hazards. Later this year, follow-up training will be provided at the pilot plant in Russia (Smolensk) and the pilot plant in Ukraine (Zaporizhzhya).

## 8.2 Emergency Operating Instructions

*Speaker: Mike Daus; Ciel Consultants, Inc.*

Emergency operating instructions (EOIs) define actions that nuclear power plant operators must take in an emergency to stabilize the reactor and mitigate consequences of an accident or other abnormal event. Two types of EOIs are used in today's nuclear power plants: event-based and symptom-based.

Before the 1979 accident at Three Mile Island, event-based instructions were used at U.S. plants. The EOIs for many Soviet-designed nuclear power plants still are of this type. Event-based instructions require operators to first identify the cause of a problem, such as loss of power, before responding.

By comparison, symptom-based instructions enable faster and more effective decision making. These instructions specify responses to changes in plant parameters, such as reactor pressure, water level, or temperature. By responding to those changes, operators can stabilize a reactor without first having to determine the underlying cause of the change. The time saved can prevent a disaster. Symptom-based EOIs now are used at most U.S. plants and in plants of many other countries around the world.

Ciel Consultants, Inc., is a key member of the U.S. team working to transfer the technology for developing symptom-based EOIs to host countries with Soviet-designed reactors. In close cooperation with managers of the Chernobyl nuclear power plant, Ciel is teaching procedures writers at that plant how to produce symptom-based EOIs for the still-operating Unit 3 reactor.

Chernobyl staff interest in developing symptom-based EOIs for their plant began in late 1995, when plant personnel toured an American nuclear power plant to observe how such instructions are implemented in the United States. Chernobyl subsequently asked the United States for technical assistance with EOI development.

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(a) To obtain a copy of the report, *Reactor Core Protection Evaluation Methodology for Fires at Soviet-Designed Nuclear Power Plants*, contact Rich Denning at telephone (614) 424-7412, fax (614) 424-5601, or e-mail: <denning@battelle.org>.

In March 1996, the U.S. team delivered state-of-the-art computer equipment and software to Chernobyl to support the EOI development process. Ciel began its collaboration with Chernobyl procedures writers in June 1996 by traveling to Ukraine to introduce formally the concept and philosophy of symptom-based EOIs. Ciel described the underlying concepts, provided a history of EOI development in the United States, and outlined the elements of a symptom-based EOI program for Chernobyl personnel. Plant management subsequently created a development team to draft symptom-based EOIs for Unit 3.

The Chernobyl team, working closely with Ciel, has progressed quickly through most of the major steps involved in the instruction development process. By mid-February 1997, the Chernobyl procedures writers had

- Developed final drafts of flowcharts and underlying technical documentation for five EOIs.
- Created a writer's guide and obtained approval for its use.
- Developed the EOI program document and received approval.
- Designed the programs for verifying and validating the newly developed EOIs.

The Chernobyl procedures writers have drafted their plan for training plant operators to use the EOIs. In addition, they have completed the support instructions in flowchart format for the Chernobyl EOIs.

In mid-February 1997, Ciel staff were onsite in Ukraine participating in an analytical workshop session with the Chernobyl writers. During that session, they

- Reviewed the most current drafts of the EOI flowcharts, writer's guide, and associated technical documentation.
- Reviewed and finalized the draft EOI support instructions.
- Finalized the plans and procedures for verification and validation.
- Trained the writers on techniques for validation scenarios.
- Reviewed the operator training program.

Ciel credits the rapid progress on this effort to the high level of commitment demonstrated by its Chernobyl partners. Chernobyl management's contributions to the effort also have been a key factor. For example, throughout this association, the Chernobyl procedures writers have shared the travel responsibility associated with this collaboration by alternating trips to each others' countries with the Ciel consultants. Based on past experience with this effort, Ciel representatives estimate that the EOI program for Chernobyl will be implemented fully by the end of September 1997.

## 8.3 An Overview of Projects at the Chornobyl Shelter

*Speakers: Dennis Kreid; Pacific Northwest National Laboratory; and Jack Woods; Stone & Webster Engineering Company*

The Chornobyl accident in April 1986 destroyed the Unit 4 reactor, leaving 190 metric tons of highly radioactive fuel in a twisted mass. To contain the contamination, plant personnel worked steadily for the next seven months, constructing a massive steel and concrete structure over the devastated reactor.

The 20-story shelter (or Ukrytie, as the Ukrainians call it) is deteriorating. Moisture from rain, cleanup work, and condensation has found its way inside and is slowly dissolving the fuel-containing masses into radioactive dust, contributing to a potential criticality state. In addition, the shelter itself, erected partially upon the damaged remains of the Unit 4 building, is unstable structurally; it also is sighted in an earthquake zone rated 4 to 5 on the Richter scale. These factors pose risks to workers assigned to shelter cleanup activities.

Recognizing those risks, Ukraine and members of the international community have launched efforts to improve the safety of shelter operations and to convert the shelter and damaged reactor into an ecologically safe system. The United States is supporting those efforts in two key ways:

- working with Ukraine to supply Chornobyl shelter workers with basic equipment to meet immediate safety needs
- working with the international group to develop final solutions to the structural and other problems with the shelter.

### 8.3.1 Chornobyl Shelter Safety Equipment Needs

The work to supply Chornobyl shelter workers with basic safety equipment began with an initial assessment of shelter needs in May 1996. The U.S. team compiled a lengthy list.

It became readily apparent that workers involved in Chornobyl cleanup activities had some major basic needs for certain kinds of safety improvements. Further, it also was obvious that neither the Chornobyl plant nor shelter organization had the financial resources with which to obtain those improvements (equipment or training).

The U.S. team set out to make that needed equipment and training available to shelter workers. The overriding criterion guiding the team's choices was that the equipment and training must yield immediate or near-term, direct improvements in worker safety. After applying this criterion, the team chose four emphasis areas:

- dose reduction
- nuclear (criticality) safety monitoring
- dust suppression
- industrial safety enhancements.

The dose reduction effort will provide equipment, training, and mentoring to improve worker radiological protection and infrastructure. As part of this task area, the United States is providing shelter workers with electronic dosimetry, dose-tracking software, and portable survey instruments. The radiation protection technicians will receive standards-based training. Engineered controls and dose modeling software will be provided. The U.S. team also located American supplies of excess calibration sources, radiation-protection clothing, and respirators for the shelter workers. As of mid-February, deliveries of approved equipment items had started and will extend through September 1997.

Under the nuclear criticality monitoring task, U.S. experts will install neutron monitoring equipment inside the shelter. Eight detector pods will be provided for monitoring six key fuel-containing locations in the shelter. The monitoring will help assess causes of observed changes in neutron activity levels, define any measures that might be required to mitigate those changes, and help ensure worker safety. System delivery is expected by July 1997. The data collected with the system will provide a basis for assessing longer-term needs for criticality monitoring in the shelter.

The dust suppression equipment is intended to improve radiological conditions inside the shelter. The United States will provide three airless sprayer units; those units already have been purchased. Shelter cleanup workers will use the portable self-contained sprayers to apply decontamination solution and fixatives in shelter periphery access ways and support areas. Efforts funded by the Chernobyl shelter are directed at developing a system for dust suppression in the event of a major shelter structural failure. Workers plan a demonstration test of a Russian-developed foam product, EKOR, for application in severe dust conditions.

Equipment for industrial safety also is being purchased. Basic items such as hard hats, fall-protection devices, and lightweight tools are expected to yield immediate improvements in worker safety. Much of the equipment on order, such as jackhammers, compressors, drills, and saws, is to provide improved access ways and support areas in the shelter peripheries and to provide access to areas inside the shelter not yet entered since the 1986 accident.

The U.S. Department of Energy has approved the purchase of all safety equipment mentioned above. Most of that equipment is on order already; delivery of all will be complete by the end of September 1997. In addition, Chernobyl shelter staff have expressed needs for thermoluminescent dosimetry systems, respirator cleaning and testing, and additional training in dose reduction techniques. A steam-water

vapor-vacuum surface cleaner for dust suppression also is on Chornobyl's list. Shelter staff have requested communications equipment (e.g., two-way radios) for use inside the shelter. The U.S. team has sought approval to purchase those items for delivery to the shelter as well. Availability of these items will further develop the shelter infrastructure capabilities for support of the larger forthcoming tasks.

U.S. efforts to make available these types of safety equipment to Chornobyl shelter workers have provided a head start to the European Commission's proposed implementation of short-term measures for the shelter.

### **8.3.2 International/European Commission Shelter Project Task Descriptions**

In May 1996, the United States became involved in an international effort to develop design solutions to structural problems at the Chornobyl shelter enclosing Chornobyl's destroyed Unit 4 reactor. At that time, U.S. technical staff were primarily observers to the work being done by the European Commission. However, between May and August, the U.S. role expanded significantly to that of leader in the effort. The United States arranged to provide the commission with technical help from industry experts in engineering, project management, and costing and scheduling. U.S. industry participants include Stone & Webster Engineering Company, Bechtel National, Parsons Power Group, Science Applications International Corporation, and Sciencetech.

The commission's long- and short-term measures project ended in October 1996. The group's recommendations were presented in a draft report delivered at the same time. In all, 23 measures were proposed, representing a composite of the best ideas from all alternatives or scenarios considered for the shelter.

In December 1996, the European Commission presented its recommendations to the G-7 and Ukrainian officials at meetings in Slavutych. Those recommendations met with only partial acceptance. Immediately following those meetings, the U.S. International Shelter Project working group was formed. Participants include the industry representatives mentioned above plus technical experts from two U.S. Department of Energy national laboratories. The working group's charge is to complete detailed cost and schedule estimates for the European Commission's recommended measures and to identify those that can be started promptly. The outcome of these activities will help determine the proportion of support to be pledged by each G-7 country on behalf of the Chornobyl shelter work.

In addition to the European Commission, G-7 countries, and the U.S. working group, many host country organizations in Ukraine and Russia play active roles in the efforts to resolve outstanding safety issues at the Chornobyl shelter. From Ukraine, these organizations include the shelter operations department of Chornobyl nuclear power plant, NIISK (the Ukrainian Academy of Engineering Sciences, i.e., the Ukrainian construction institute), the Ukrainian Academy of Sciences Interdisciplinary Scientific and Technical Center - Shelter, and the technical center of the Nuclear Regulatory Agency, Ukrainian Ministry of Environmental Protection and Nuclear Safety. Russian organizations involved in Chornobyl efforts are the Khlopin Radium Institute and VNIPIET (All-Russian Planning and Design, Research and Technological Association) in St. Petersburg and the Kurchatov Institute in Moscow.

### 8.3.3 European Commission Project Results and Short-Term Measures

The European Commission began its Chernobyl Shelter Project in 1992 with an international competition aimed at eliciting design solutions for the disintegrating Chernobyl shelter. From a field of 400 design submissions, the commission selected eight for further investigation. In July 1995, that effort resulted in a design known as the Alliance Shelter 2. However, because of the high costs and massive size of the Alliance design, it was rejected. In May 1996, the European Commission began another international effort, this time to determine alternatives to the Alliance design and to recommend one that would resolve the safety issues at the Chernobyl shelter.

As part of the U.S. Department of Energy's efforts to improve the safety of Soviet-designed reactors, several U.S. staff became involved with the European Commission work, primarily as observers. By early August 1996, however, those specialists were asked to organize a team of U.S. industry experts to support the commission's efforts to develop a reasonable alternative for the Chernobyl shelter. The newly formed U.S. working group comprised specialists from Stone & Webster Engineering Company, Bechtel National, Inc., Parsons Power Group, Inc., Science Applications International Corporation, and Sciencetech.

The U.S. working group directive was to help the European Commission develop a technically sound solution to the issues at the Chernobyl shelter and to assist in generating cost estimates from which to develop a financially feasible budget for implementing the solution. The approach taken by the team was to evaluate five scenarios or courses of action and to arrive at a recommended course of action for the commission.

The U.S. working group studied five alternatives:

1. Do nothing; continue current situation.
2. Define and implement short-term measures; continue active risk management as a long-term measure.
- 3a. Build a small shelter around the existing shelter; proceed to early removal of fuel-containing debris.
- 3b. Build a long-lived shelter to contain and confine the existing shelter in case it collapses; proceed to removal of fuel-containing masses when appropriate.
4. Contain and confine the entire shelter with a long-lived earth shelter; proceed to remove fuel with heavy equipment if required.
- 5a. Shield, stabilize, and contain the shelter with cementitious material and confine the fuel-containing masses with a long-lived shelter. Proceed to fuel removal when appropriate.
- 5b. Shield, stabilize, and contain the shelter with cementitious material. Keep the fuel-containing masses in place. Proceed to removal if required.

Based on the evaluation, the U.S. working group is recommending both short- and long-term measures. That recommendation incorporates the best features of each of the five scenarios the team examined. The recommendation comprises four primary activities:

- Reduce the potential for accidental collapse of the existing shelter.
- Reduce the consequences of accidental release of contamination.
- Manage the fuel-containing material inside the shelter; manage the radioactive material in and around the shelter.
- Increase the safety of current shelter operating conditions.

Of those four activities, the team's primary emphasis was on stabilizing the structure of the existing shelter to reduce the potential for accidental collapse.

Each of the four activities involves both short- and long-term measures. The short-term measures will reduce the current hazards and risks, making the existing shelter safer than it is now. The longer-term measures will make the shelter safe by lowering the risks and hazards to levels considered to be reasonable, achievable, and tolerable and by ultimately removing the fuel-containing material now inside.

The course of action recommended by the U.S. working group involves a multi-year effort to be done in three phases. The proposed timeline for implementing the recommended action shows Phase 1 beginning in 1997 with the implementation of 17 short-term measures in four categories:

- structural stabilization
- monitoring
- nuclear safety
- industrial and environmental safety.

Phase 2 entails preparing the shelter for long-term conversion. The U.S. working group has agreed that those preparations include shielding and controlled access, which should proceed in parallel with the short-term measures of Phase I. Also being discussed are construction of a new confinement structure, deconstruction/removal of unstable pieces, and possibly partial removal of fuel-containing material. No decisions have been made on these last three items, however. The schedule projected for Phase 2 extends through 2025.

In Phase 3, the shelter would be converted into an ecologically safe site, some time after the year 2025. Specific tasks in this phase would include replacing the existing structure with one that meets all criteria for ecological safety. Phase 3 also encompasses removal of all remaining fuel-containing material when Ukraine is ready to do so.

The U.S. working group calculated the costs for each of the five scenarios (and subsets) evaluated during this study. The estimated costs range from a low of (U.S.) \$180 million for implementing only the short-term measures to \$424 million for a new structure consisting of cementitious fill coupled with bridge confinement. On the basis of estimated costs alone, no single long-term structural solution is the clear winner.

In retrospect, the U.S. working group's participation in the European Commission study helped steer the commission away from choosing a single alternative with which to resolve the shelter issues. Instead, the working group guided the commission toward the emplacement of short-term measures as a way to "jump-start" the work while preserving design options for the later phases of the work. The four projects already under way at the shelter as part of the U.S. effort to improve worker safety—dose reduction, nuclear criticality monitoring, dust suppression, and industrial safety equipment enhancements—are congruent with short-term measures recommended by the European Commission's original study.

### **8.3.4 In Summary**

U.S. involvement in the International Shelter Study has facilitated great progress in meeting the safety challenges posed by the Chernobyl shelter. However, much work remains to be done to fully meet those challenges. For that reason, the effort is now best described as "a work in progress."

## **8.4 Chernobyl Reactor Deactivation, Decontamination, and Decommissioning Project - Concept, Status, and Path Forward**

*Speaker: Tom Wood; Pacific Northwest National Laboratory*

The objective of the work is to support the orderly deactivation, decontamination, and decommissioning (D,D, &D) of reactor Units 1, 2, and 3 at Chernobyl, consistent with timely reactor shutdown, regional economic stability, and operating safety. The work is aimed at developing a sound technical and regulatory basis for D,D, &D activities for RBMK reactors on an international basis. (RBMK reactors operate in Russia, Ukraine, and Lithuania.) In addition, the project is intended to foster development of the capability for D,D, &D planning and implementation within the Chernobyl nuclear power plant and the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology. The D,D, &D project was initiated early this fiscal year based on Ukraine's decision to close Chernobyl Unit 1 earlier than planned because of problems with pressure tube integrity.

The U.S. Department of Energy previously was involved with a study for D&D planning for reactor Unit 1 at the Leningrad nuclear power plant. From that work, it became apparent that the Russian regulatory basis for decommissioning RBMK reactors was insufficient and that the situation likely would be similar in Ukraine. This fact, in addition to the difficulties with operating the Chernobyl site and the

overall safety infrastructure in the Ukrainian nuclear industry, pointed to the need for U.S. technical support for Chernobyl D,D, &D. The work demonstrates the willingness of the United States to support Ukraine in solving a challenging problem that is critical to shutting down the reactors by 2000. In addition, early involvement of the United States was determined to be critical to building Ukrainian capabilities in D,D, &D as soon as possible.

Initial work in FY 1997 focused on three tasks:

- Transfer awareness of U.S. D,D, &D technologies and processes to senior Chernobyl and Ukraine regulatory management.
- Conduct a survey of Unit 1 readiness and resources for deactivation. This survey was conducted in February 1997 by engineers from Bechtel Hanford Company and Pacific Northwest National Laboratory.
- Clarify risk reduction benefits of deactivation steps. Closing and achieving adequate cleanup of nuclear sites is part of an overall responsible nuclear safety culture that the United States is working with Ukraine to create.

The project concept is to transfer U.S. technology in a three-step process:

- Familiarize personnel with D,D, &D technology used at U.S. Department of Energy sites and commercial reactor sites.
- Select promising technologies for Chernobyl.
- Conduct testing and demonstrations of technologies, as well as associated training, at Chernobyl.

In support of building a sustainable safety culture and capabilities in Ukraine, the guiding principle of the work is to maximize the work done by Ukrainians. The intent is to build a D,D, &D technical capability within the Chernobyl plant organization that can be applied at Chernobyl as well as at other nuclear power plants in Ukraine. This goal is accomplished by defining regional D,D, &D skills early to enable Chernobyl officials to plan the necessary labor force and by providing U.S. technology and supplies as training resources.

Proceeding soon with D,D, &D has economic and safety incentives. Some 6,500 staff continue to work at Chernobyl, though Unit 3 is the only reactor now operating. The longer the shut-down reactors remain in their current status—without proceeding with deactivation—the greater the risk that highly qualified nuclear experts could leave to apply their skills elsewhere. However, the skills of some of those staff could be put to productive use in D,D, &D as soon as training can proceed. The safety incentives stem from the same situation. Though reactor Units 1 and 2 are not operating, they share electrical and fire protection systems with operating Unit 3. Therefore, it is important that qualified staff are retained to

maintain systems at all the reactors until deactivation proceeds. The longer the fate of the reactors is undecided, the greater the risk that those staff will leave, thus potentially increasing safety risks.

Despite the benefits of moving ahead with D,D, &D, several challenges are associated with the work. The activities can be complex and costly. Significant nuclear safety issues associated with the shutdown of RBMK reactors will need to be resolved. The key issues have to do with the extent of decontamination necessary to minimize worker radiation doses, minimize the amount of resulting liquid waste, and control future environmental contamination. The regulatory framework for D,D, &D is just emerging in Ukraine; the nation's regulatory organization currently consists of only 70 people.

Though Ukraine has agreed in principle to shut down the Chernobyl reactors by 2000, no implementation plan yet exists to do so. In 1995, the British-based company AEA Technologies prepared a report commissioned by the European Union called *Preparation of Decommissioning Operations for the RBMK Reactors No's 1, 2, and 3 at Chernobyl*. However, the report represents a vision of the decommissioning outcome rather than a plan to implement it.

Chernobyl plant officials have expressed interest in moving ahead with D,D, &D work and proposed the following deliverables for a joint project:

- a comprehensive radiological and structural engineering survey of Unit 1
- a safety assessment report and detailed decommissioning work plan for Chernobyl to support the Chernobyl license application for the D,D, &D phase
- background research on issues relevant to these documents, including a study of alternative techniques for cooling pond decommissioning.

With limited resources by both countries, the work must be prioritized. It is expected that in FY 1997, work can be completed on developing the requirements for the engineering survey and for the safety assessment report, and for defining options for the cooling pond. Also this year, U.S. participants will transfer software and data to the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology, in preparation for the D,D, &D work. The software, developed by Pacific Northwest National Laboratory, will enable Chernobyl staff to estimate costs for reactor decommissioning activities and assess the radiological and chemical risks associated with various decommissioning options. If the proposed work moves ahead as planned, the remaining work in the joint project is expected to be completed in FY 1998 and 1999. The results of that work will determine the scope of future U.S. involvement.

A particular area of importance related to Chernobyl D,D, &D and plant safety is its heat plant. An existing 70-MWt heat plant is operating at Chernobyl. The heat plant provides heat to help keep the reactor in a safe standby mode when it is not operating. Thus, a reliable heat plant is needed to support deactivation activities. In addition, the heat plant provides a safety benefit for the operating Chernobyl Unit 3 reactor if it should need to be shut down in an emergency, by keeping the reactor coolant from

freezing and breaking the pipes. Pipe leaks would cause release of radioactive materials. In addition, a frozen cooling loop could prevent heat surrounding the reactor core from escaping, which could lead to a core meltdown.

The existing heat plant cannot meet the total site demand, and the thermal energy requirements of D,D, &D efforts will be even higher. In addition, the reliability and remaining life of the existing heat plant are limited. To alleviate the situation, it may be possible to increase the capacity of the existing heat plant by adding new boilers. Another option is to complete a partially constructed replacement plant at Chornobyl that was put on hold because of lack of Ukrainian resources to complete it. In the short term, the United States has committed to providing Ukraine with technical assistance in identifying options for providing adequate heat at the site. U.S. officials are discussing potential further U.S. involvement with plant management. A decision about work scope is expected to be reached in mid-1997.

## **8.5 Chornobyl Center for Nuclear Safety, Radioactive Waste and Radioecology: U.S. Perspective**

*Speaker: Roger Anderson; Pacific Northwest National Laboratory*

The driving force behind establishment of the Chornobyl Center for Nuclear Safety, Radioactive Waste and Radioecology was a need to develop the institutional capacity, indigenous to Ukraine, to provide scientific support to the Ukrainian nuclear industry.

The center's move from concept to reality was accomplished in a little more than one year. In May 1995, Ukraine's President Kuchma and U.S. President Clinton stated their shared intent to establish an international center to address the issues at Chornobyl. From June through August 1995, representatives of Ukraine's nuclear regulatory agency Ministry for Environmental Protection and Nuclear Safety, the Chornobyl nuclear power plant, and the United States cooperated in preparing a preliminary development plan. In December 1995, the Chornobyl Center was included in the G-7 Action Plan addressing Chornobyl closure. Then, in April 1996, President Kuchma signed a decree to establish the center and named Dr. Valery Glygalo as the center's coordinating director. At the same time, Ukraine and the United States signed a Memorandum of Understanding outlining support for the creation of the center. The most recent milestone in the center's development history occurred in January 1997, when the Chornobyl nuclear power plant signed a protocol to establish a Chornobyl Center subsidiary, the Slavutych Laboratory for International Research and Technology. That protocol also contained commitments for initial facilities and staffing. Most significant was the plant's agreement to transfer Mr. Anatoly Nossovsky from Chornobyl to the center to serve as center deputy to Dr. Glygalo. This agreement reflects the outstanding support of Chornobyl nuclear power plant for the center concept.

That original concept was underlain by five key objectives:

1. to develop sustainable operational safety programs that support Ukrainian nuclear power plants
2. to help develop and maintain in-country expertise in nuclear sciences
3. to address decontamination and decommissioning, spent fuel, and waste management issues at Chernobyl and elsewhere in Ukraine
4. to provide a means for international collaboration in addressing environmental, ecological, and health issues for those areas affected by the 1996 accident
5. to help mitigate the socioeconomic impacts associated with the ultimate shutdown of the Chernobyl nuclear power plant.

The main emphasis throughout these objectives is the concept of "sustainability." The Ukrainian and U.S. partners working to bring the center concept to reality intended to create an institution eventually able to sustain itself without outside assistance.

The intent is that the center will develop relationships with other sources of technical expertise from around the world as well as from within Ukraine, thus becoming a truly international partnership. Such collaborations will create the potential for research and development spinoffs, as well as encourage contracts with other service providers. These activities, in turn, will enhance the center's position as a source of direct employment for Ukrainian scientists.

Although still new, the center already is attracting participants and attention from the international community. Dr. Glygalo serves as an advisor on two projects that Canada has initiated in Ukraine. France and Germany, through the RiskAudit firm in Kiev, have begun joint projects also involving Russia and Belarus. Italy has announced its commitment to provide \$3 million in financial support to the center. Potential collaborative efforts with the United Kingdom and Japan are being explored. Many other countries around the world have extended formal expressions of interest in doing work with the center.

The United States is playing a key role in establishing the Chernobyl Center as a viable, sustainable entity. As part of the U.S. Department of Energy's effort to improve international nuclear safety, U.S. specialists are involved with the center on three main fronts: management support, infrastructure development, and joint projects.

The U.S.-provided management support ranges from helping to plan for center development to assisting with center outreach and integration activities. U.S. scientist Bryan Gore has been on assignment in Slavutych since May 1996, working closely with key representatives of Ukrainian agencies and the Chernobyl nuclear power plant on plans for center development. Other U.S. experts will provide training in research and development management techniques to staff of the new center in the coming months.

The United States also is supporting the center's efforts to develop its infrastructure. A key piece of that infrastructure is the state-of-the-art telecommunications system installed recently in Slavutych. The system offers satellite-based voice, fax, and high-speed data transmission between the center's offices and U.S. Department of Energy sites and other sources of interaction and assistance in the United States. The addition of videoconferencing capability is being planned now. Another important constituent of the center's developing infrastructure is a facility for acquiring and processing nuclear data for use in safety and radiological assessments. U.S. experts have provided sophisticated computer programs and equipment to enable the center to access specific data sets and information available electronically outside Ukraine. Help with office space and basic equipment also is being provided.

In line with the objective to establish the center as a sustainable entity, the United States already has initiated several technical projects with center staff in Ukraine. Among those is an analysis of hazards posed to Chornobyl Unit 3 by the shelter surrounding the destroyed Unit 4.<sup>(a)</sup> The analysis results are undergoing technical peer review. In another joint effort, U.S. and Ukrainian researchers will develop a plan for managing Ukraine's spent nuclear fuel. U.S. specialists are providing training and technology transfer as part of the planning for ultimate D,D & D of the Chornobyl nuclear power plant. Center and U.S. researchers also are working on an assessment of needs at the Chornobyl plant and shelter for three-dimensional modeling. An assessment of robotics technologies for potential use in shelter activities also is planned.

The immediate next steps in center establishment are facilities renovations (to provide permanent office space), staffing, management training, and international coordination and integration. Center research staff will comprise personnel transferred from Ukrainian government agencies and from the Chornobyl nuclear power plant. On March 1, the plant transferred 10 to 15 highly qualified personnel to the center. The United States will provide various types of training to those staff--management of research and development organizations and projects, administrative functions, and English language skills. U.S. experts also will assist the center's efforts to coordinate and integrate with the international nuclear community through informal information-sharing.

Looking ahead a little farther, we envision that the Chornobyl Center will collaborate with others in several major project areas:

- operational safety and radiological protection training (at both Chornobyl nuclear power plant and other sites in Ukraine)
- shelter monitoring, stabilization, and cleanup
- Chornobyl nuclear power plant closure and decommissioning

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(a) A summary report on this effort is available on the Internet at <http://insp.pnl.gov:2080>. Look under the category "Reports," then "Technical Reports."

- development, demonstration, and use of new technologies - In this area, the center could develop a test bed facility in which purveyors of waste management and remediation technologies could test their products under monitored and controlled conditions.

U.S. commercial firms and contractors involved in U.S. Department of Energy's international nuclear safety activities are urged to consider how they can use the Chernobyl Center. The center's long-term success as an indigenous, sustainable research institute is dependent upon such collaborations. The center offers many possibilities for joint work; some suggestions include the following:

- Identify and establish scientific support roles for the Chernobyl Center in implementing the short-term measures at the Chernobyl shelter.
- Engage the center in data acquisition and characterization tasks to build information management resources and credibility.
- Create opportunities for center participation in commercial tenders and technology development ventures, to further the sustainability objective.
- Establish twinning relationships with center staff members to enhance business management and joint technical development capabilities.
- Participate in funding facility renovations and equipping of offices and laboratories for the center.
- Consider participating in developing a multipurpose facility for technology testing and demonstration.

To discuss ideas for future collaborations with the Chernobyl Center, contact Roger Anderson, Pacific Northwest National Laboratory, telephone (206) 528-3300, facsimile (206) 528-3552, or e-mail <andersrg@battelle.org>.



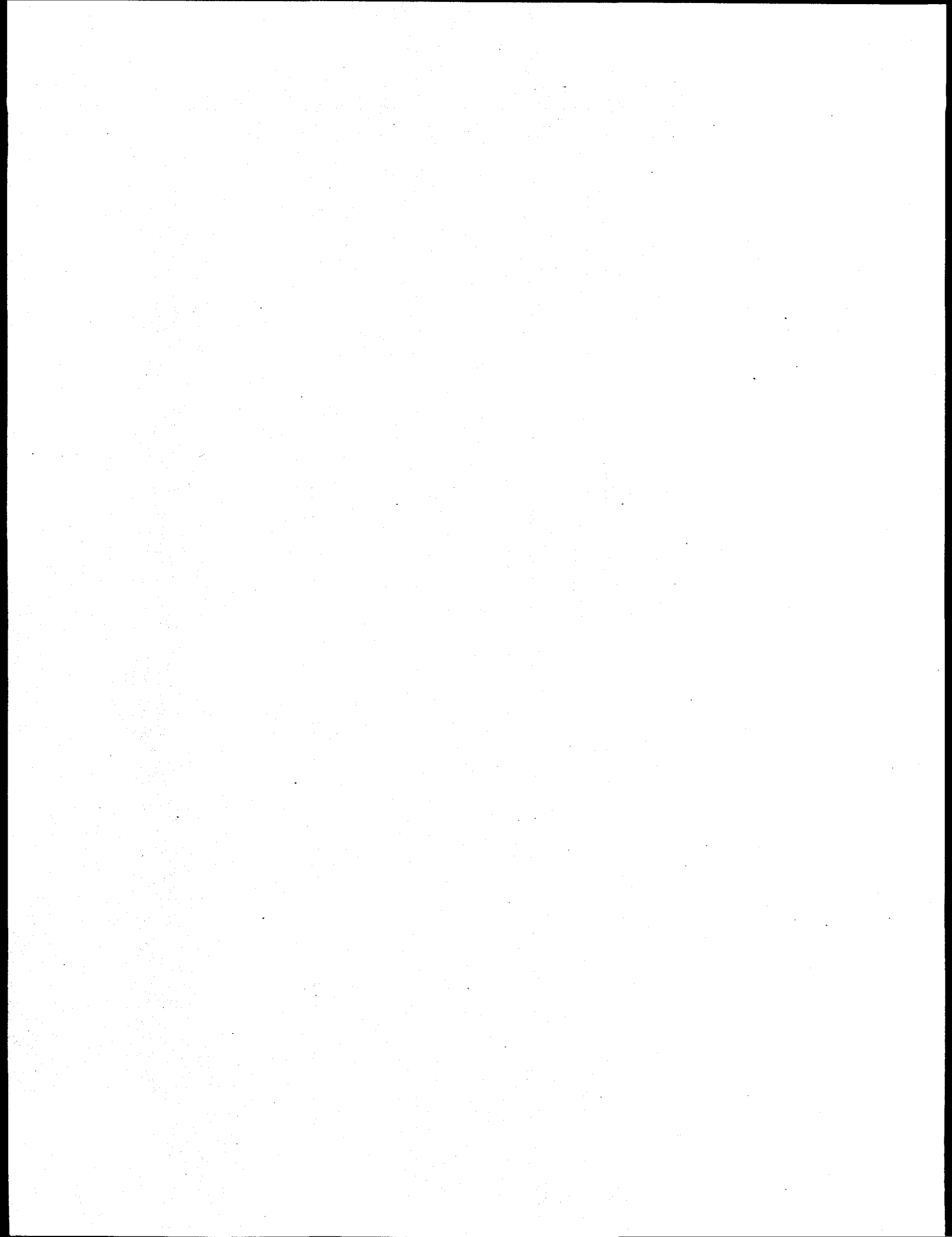
## 9.0 Status of Action Items from the May 1996 Contractor Information Exchange

Action Item	Status
<p>Develop methods for stronger regulatory involvement in training and other projects.</p>	<p>To help provide host-country regulatory organizations with the tools and information necessary to perform regulatory oversight of U.S.-sponsored nuclear safety projects, ongoing and new projects have included</p> <ul style="list-style-type: none"> <li>- working with host-country regulators to develop guidance for reviewing and approving symptom-based emergency operating instructions. This work also will provide a foundation for more focused and effective regulation of other operational safety activities such as training and simulator development.</li> <li>- working with Russian regulators to develop guidelines for developing probabilistic risk assessments</li> <li>- providing training to Ukrainian regulators in preparation for licensing the dry cask storage system for spent nuclear fuel at the Zaporizhzhya nuclear power plant. U.S. specialists have provided Ukrainian regulators with training in computer codes for safety analysis and have transferred the actual computer codes. In addition, training was provided in the regulation of spent fuel transportation.</li> <li>- providing training to Russian regulators in areas such as emergency preparedness, quality assurance, safety analysis, and event reporting and analysis</li> <li>- working with Ukrainian regulators, in support of the State Department and in collaboration the U.S. Nuclear Regulatory Commission, to establish a supplemental funding convention for nuclear liability.</li> </ul>
<p>Create a platform for sharing information about deliverables and data. Such information will be compiled and made available to participants via the Internet site and other avenues.</p>	<p><i>Hard copies</i> of deliverables are available through the Resource Center Assistant, Nancy Jackson, at (509) 372-4679, or E-mail: <a href="mailto:na_jackson@pnl.gov">na_jackson@pnl.gov</a></p> <p><i>Abstracts</i> of deliverables are being prepared for placement on the Internet home page. Participants will be notified when the abstracts are available electronically.</p>

Action Item	Status
<p>Develop better methods for scoping and selecting projects, to obtain the most useful results that can be leveraged for maximum impact.</p>	<p>Project selection criteria now are formalized. A summary of the criteria and process for project selection appears as Appendix H in the report, "Improving the Safety of Soviet-Designed Nuclear Power Plants," November 1, 1996, Status Report, published by the U.S. Department of Energy's Office of Nuclear Energy, Science and Technology. For a copy, contact Nancy Jackson at the phone or fax number given on the previous page.</p>
<p>Prepare a plan for more effective technology transfer. This includes convening a working group to focus on technology transfer and publishing technology transfer successes.</p>	<p>In summary At the May 1996 Contractor Information Exchange meeting, an ad hoc working group was established to identify ways to improve technology transfer. That group developed a "white paper" on tech transfer mechanisms. At the quarterly program meeting in July 1996, the technology integrators were asked to evaluate technology transfer in their specific areas, using the white paper as a stimulus for that review. The technology integrators then identified specific areas requiring enhancement to optimize technology transfer. The result of that review is summarized in a revised draft white paper, <i>Enhancing Technology Transfer in DOE's International Reactor Safety Projects</i>. The paper, which appears in Appendix D of this report, should be viewed as a status of, rather than a program plan for, technology transfer. See Section 6.0 of this report for more details on technology transfer projects under way.</p>
<p>Document successes on a regular basis.</p>	<p>PNNL has excerpted "success letters" from contractors and other participants in the revised <i>Status Report</i>. Other successes are being documented in technology fliers and under the "news" category of the Internet site.</p>

## **Appendix A**

### **Agenda for the Information Exchange**



**REVISED AGENDA**  
**Contractor Information Exchange**  
**Improving the Safety of Soviet-Designed Nuclear Power Plants**  
**DoubleTree Park Terrace Hotel**  
**1515 Rhode Island Avenue, N.W.**  
**Washington, D.C. 20005**

**TUESDAY, FEBRUARY 18, 1997**

5:30 p.m. Reception, State Room

**WEDNESDAY, FEBRUARY 19, 1997**

8:00 a.m. Continental breakfast and registration, Terrace Ballroom

8:30 a.m. Terrace Ballroom (Facilitator: Doug Brookman)

- Welcome, meeting preview, and follow-up from prior information exchanges  
Laurin Dodd, Pacific Northwest National Laboratory (PNNL)
- Direction of U.S. activities, recent developments and accomplishments  
Kristen Suokko, U.S. Department of Energy (DOE)
- The future of U.S./Ukraine and U.S./Russia Vice-Presidential Commissions  
Kristen Suokko, U.S. DOE
- FY1997 budget  
Dan Giessing, U.S. DOE
- Department of State perspectives on international nuclear safety  
Carol Kessler, U.S. Department of State

11:00 a.m. Break

11:15 a.m. Terrace Ballroom

- Contracting/labor rates/payments  
Jeff Ace, PNNL
- Technology transfer  
Rich Denning, PNNL

11:45 a.m. **Session Topic - Objectives and Strategies**, Rich Reister, U.S. DOE

Description: Review of objectives and strategy for completion

- Objectives, work to be done to achieve them, and end points - conditions at nuclear power plants and nuclear agencies in former Soviet Union countries when work is completed
- Where we need help
- Funding needs for work completion
- Measurement of progress and performance

12:30 - 1:45 p.m. **Lunch**, Terrace Ballroom

1:45 p.m. **Panel Discussion: Chernobyl Initiatives** (Facilitator: Caroline Chamblin)

Description: DOE's activities to address safety problems at Chernobyl

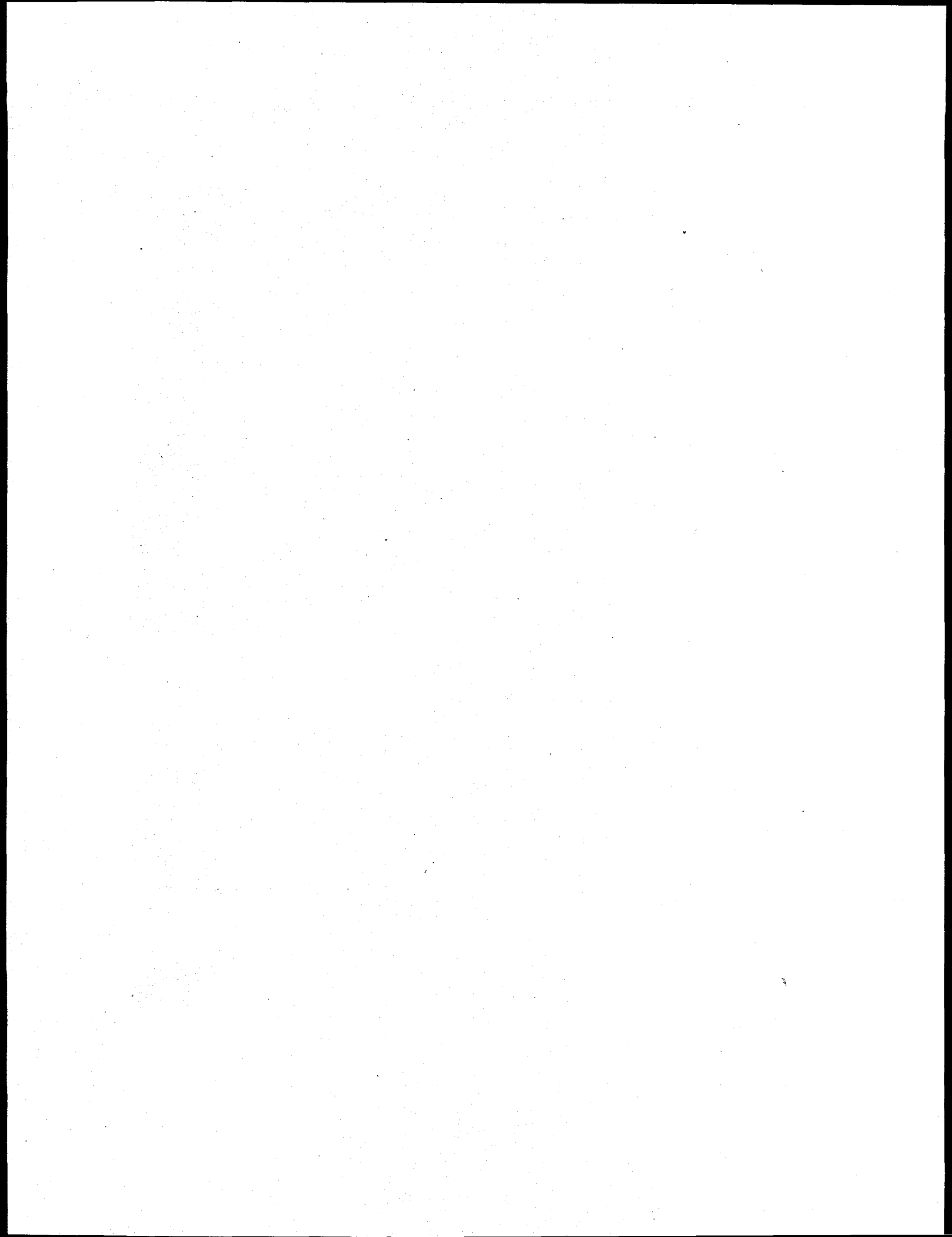
- Chernobyl overview
- Fire safety upgrades Mike Archdeacon, Bechtel National, Inc.
- Emergency operating instructions Mike Daus, Ciel Consultants, Inc.
- Shelter overview Dennis Kreid, PNNL
  - Safety needs/projects Dennis Kreid
  - European Commission project results John Woods, Stone & Webster Engineering Corporation
  - Short-term measures John Woods
  - Shelter working group activities Dennis Kreid
- Decontamination and decommissioning Tom Wood, PNNL
- The Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology Roger Anderson, PNNL

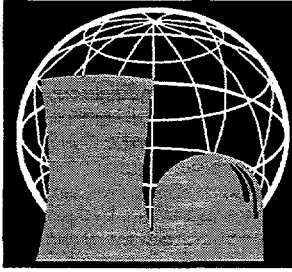
4:30 p.m. **Meeting Wrap-up**

4:45 p.m. **Meeting adjourned**

## **Appendix B**

### **List of Attendees**





## Contractor Information Exchange - Attendees February 19, 1997

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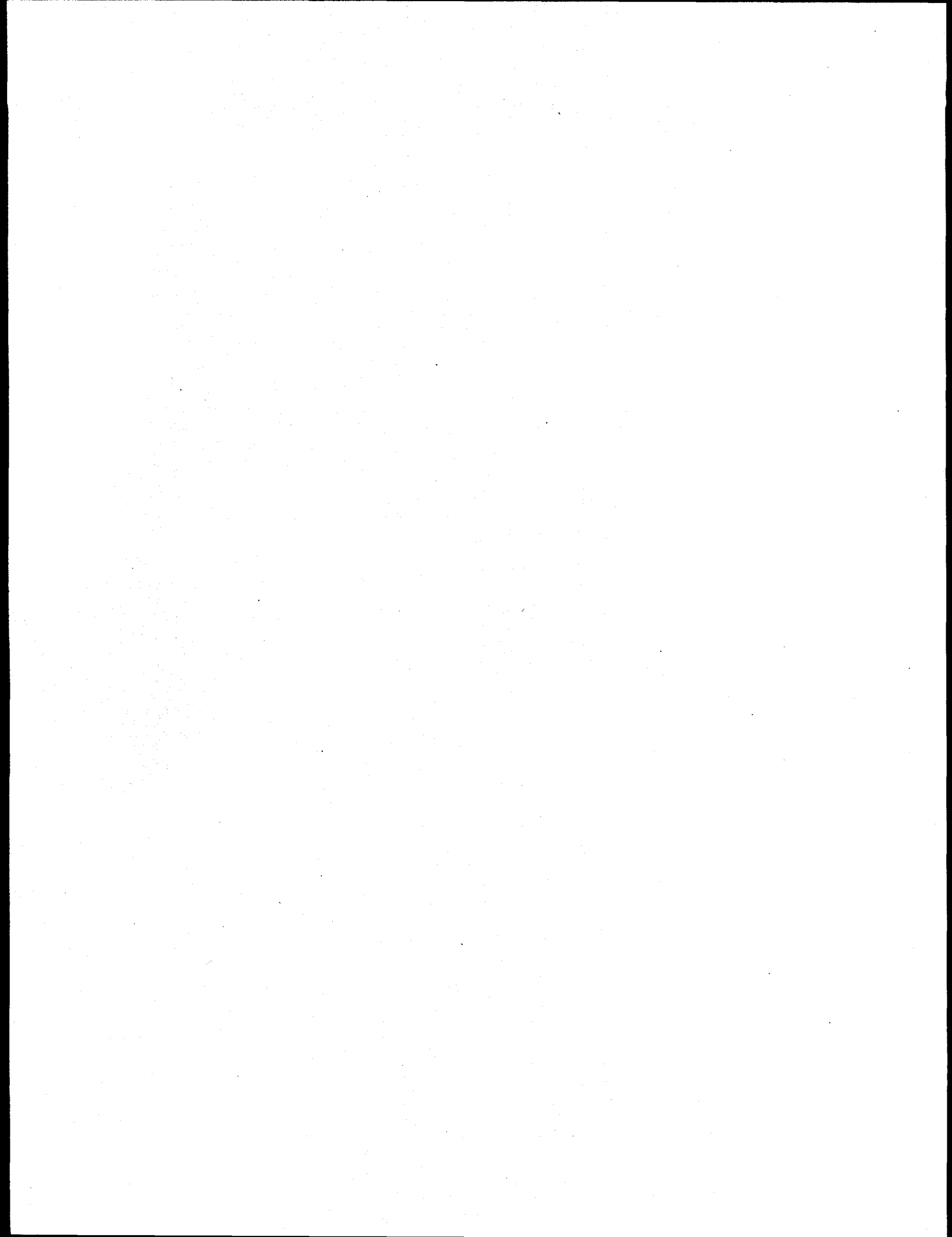
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## Appendix C

### Presentation Visuals Provided During the Information Exchange

- **Improving the Safety of Soviet-Designed Nuclear Power Plants:  
Direction and Updates** ..... C.1
- **Subcontract Rates in Former Soviet Union Countries** ..... C.7
- **Technology Transfer** ..... C.9
- **Strategy for the U.S. Department of Energy's Cooperative  
Safety Work** ..... C.15
- **Addressing Safety Issues at Chernobyl: An Overview** ..... C.21
- **Fire Safety Upgrades at Chernobyl Nuclear Power Plant** ..... C.23
- **Emergency Operating Instructions** ..... C.31
- **Chernobyl Unit 4 Shelter Projects Overview** ..... C.39
- **European Commission Project: Results and Short  
Term Measures** ..... C.53
- **Chernobyl Reactor Deactivation, Decontamination, and  
Decommissioning Project: Concept, Status, and Path Forward** ..... C.67
- **Chernobyl Center for Nuclear Safety, Radioactive Waste and  
Radioecology: U.S. Perspective** ..... C.73





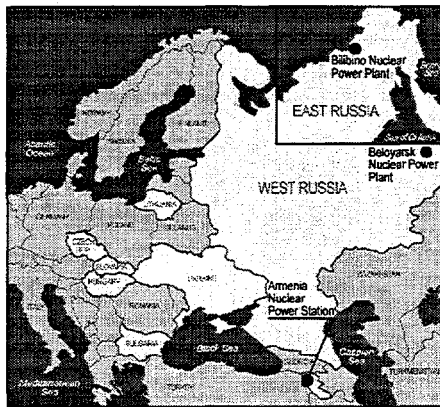
## Improving the Safety of Soviet-Designed Nuclear Power Plants: Direction and Updates

**Kristen Suokko**  
**U.S. Department of Energy**  
**Office of Nuclear Energy, Science and Technology**  
**February 19, 1997**

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## Involvement of Additional Nuclear Power Plants



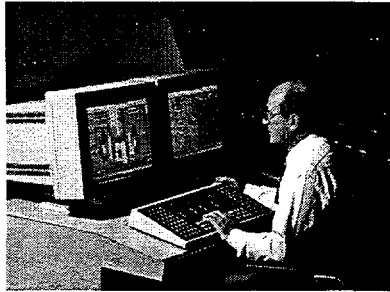
- ◆ Armenia Nuclear Power Station
- ◆ Bilibino Nuclear Power Plant
- ◆ Beloyarsk Nuclear Power Plant

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Department of Energy  
Office of International Operations  
International Energy

## Key New Projects Since May 1996



- ◆ Technology transfer
- ◆ Safety parameter display systems
- ◆ Configuration management systems
- ◆ Safety assessments

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Department of Energy  
Office of International Operations  
International Energy

## Core Conversion to Stop Plutonium Production in Russia



- ◆ U.S. policy goal: Stop Russian plutonium production by 2000
- ◆ Core conversion determined feasible
- ◆ Core design, analyses, and testing are proceeding

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## New Adjunct Office in Kiev



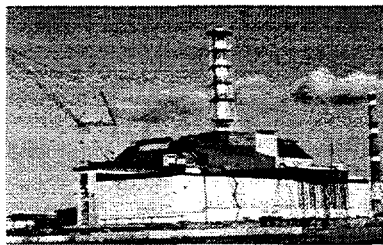
### Alex Sich:

- ◆ Supports U.S. DOE nuclear safety activities in Ukraine
- ◆ Integrates cross-cutting technologies
- ◆ Communicates status with Ukraine organizations

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## Activities at the Damaged Unit 4 Reactor

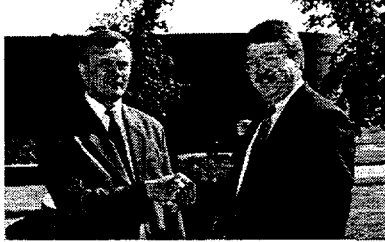


- ◆ G-7 Nuclear Safety Working Group
- ◆ Current projects:
  - ❖ Personnel dose reduction
  - ❖ Neutron criticality safety
  - ❖ Dust suppression
  - ❖ Industrial safety

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## Chornobyl Center for Nuclear Safety, Radioactive Waste and Radioecology

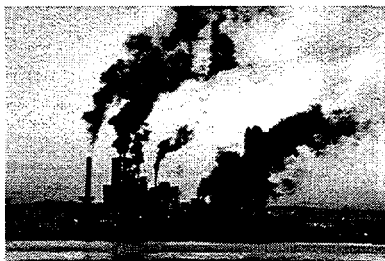


- ◆ Commitment by the Chornobyl plant and other countries
- ◆ Projects under way and planned

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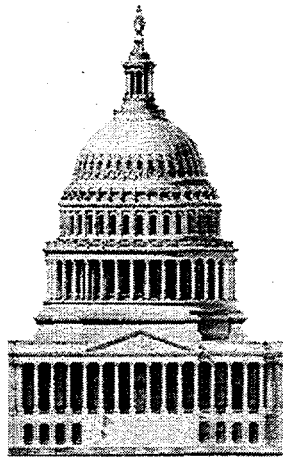


## Private Sector Initiative



- ◆ Goal: Stimulate private sector investment in Ukraine's energy sector
- ◆ Identified a number of pilot energy projects
- ◆ Completed pilot project business plan and action plan for obtaining private investment

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## Response to GAO

- ◆ **GAO audit in FY 1996**
- ◆ **DOE responded in February 1997**
- ◆ **Key issues:**
  - ❖ reactor shutdown
  - ❖ reactor life extension
  - ❖ strategic plan
  - ❖ project schedules
  - ❖ cost-sharing

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## Subcontract Rates in Former Soviet Union Countries

February 19, 1997

Jeff Ace

Pacific Northwest National Laboratory



## Subcontract Rates

- ◆ Background
- ◆ Recent Developments
- ◆ Current Status





## Technology Transfer

February 19, 1997

Rich Denning

Pacific Northwest National Laboratory



### Outline

- ◆ Status of enhancing technology transfer
- ◆ Technology transfer vision
- ◆ New technology transfer initiatives



## Technology Transfer in Nuclear Safety Projects

- ◆ May 1996 contractor meeting: working group to improve technology transfer
- ◆ White paper on technology mechanisms transfer



## Technology Transfer Mechanisms

- ◆ Information exchange
- ◆ Joint project
- ◆ Personnel exchange
- ◆ Capability transfer
- ◆ Licensing
- ◆ Joint venture



### Charge to Technology Integrators

- ◆ Evaluate technology transfer in each area
- ◆ Identify areas requiring enhancement
- ◆ Revised white paper available for review; a status of technology transfer



### Technology Transfer Vision

- ◆ Vision, goals, end points define future of nuclear safety work
- ◆ Technology transfer has a major role in the rationale underlying this vision
- ◆ Potential funding by United States and other countries is insufficient to achieve goals
- ◆ Pilot plant approach with complementary technology transfer activities



### Technology Transfer Objectives

- ◆ Facilitate the incorporation of pilot-plant upgrades at all plants
- ◆ Sustain system upgrades
- ◆ Assist in re-establishing host-country infrastructure for the supply or manufacture of nuclear safety system components
- ◆ Strengthen regulator



### New Technology Transfer Initiatives

- ◆ DC power supply
  - ❖ Assistance provided by Burns & Roe in the separation of safety and non-safety loads, sizing, and design of DC power supply systems
    - Kola 1 and 2
    - Kursk 2
    - Ignalina 2 (expected)



## New Technology Transfer Initiatives (cont)

- ❖ DC power supply system workshop - Moscow
  - Invite participation from all nuclear power plants
  - Paper on Kola experience basis for information exchange (see handout)
  - Determine status of DC power supply systems at NPPs
- ❖ Evaluate potential for in-country capability development
  - Discussions held with battery manufacturer in Russia
  - Technology transfer in Ignalina project - training and observation
  - Degree of infrastructure development will depend on size and nature of market



## New Technology Transfer Initiatives (cont)

- ◆ Ignalina control modules
  - ❖ Replacement control modules with same form, fit, and function - to be provided by Scientech
  - ❖ Second set of modules will be produced by local manufacturer following technology transfer
- ◆ Circuit breaker technology transfer
  - ❖ Safety problems with 6kV and 400V breakers identified by Rosenergoatom in survey of plants
  - ❖ Preliminary discussions held with Russian manufacturers



## New Technology Transfer Initiatives (cont)

- ◆ Valve technology transfer
  - ❖ First phase involves Rosenergoatom data-collection task
  - ❖ Scope includes valve monitoring and improved valve performance



**Strategy for the  
U.S. Department of Energy's  
Cooperative Nuclear Safety Work**

**Rich Reister  
U.S. Department of Energy  
Office of Nuclear Energy, Science and Technology  
February 19, 1997**



**MISSION**

- Reduce the risks at Soviet-designed nuclear power plants
- Implement self-sustaining nuclear safety improvements



## **VISION**

**Within a decade:**

- **Operation and regulation of Soviet-designed plants will meet internationally accepted practices**
- **Importance of nuclear safety recognized by designers, operators, and regulators**
- **Infrastructure, expertise, and resources exist in host countries to allow active participation in international nuclear safety work**



## **PROJECT SELECTION**

- **Impact on Safety**
- **Cost Effectiveness**
- **Host Country Commitment and Sustainability**



## **TECHNICAL AREAS**

**Operational Safety - management and procedures**

- **Training - operator training with simulators, SAT**
- **Maintenance - safety related equipment functions**
- **Safety Systems - alleviate major deficiencies**



## **TECHNICAL AREAS (contd)**

- **Safety Evaluations - safety basis for decisions**
- **Legal and Regulatory Capabilities - strong, independent**



## **STRATEGY**

- Pilot plant approach
- Technology Transfer
- Regulator Involvement

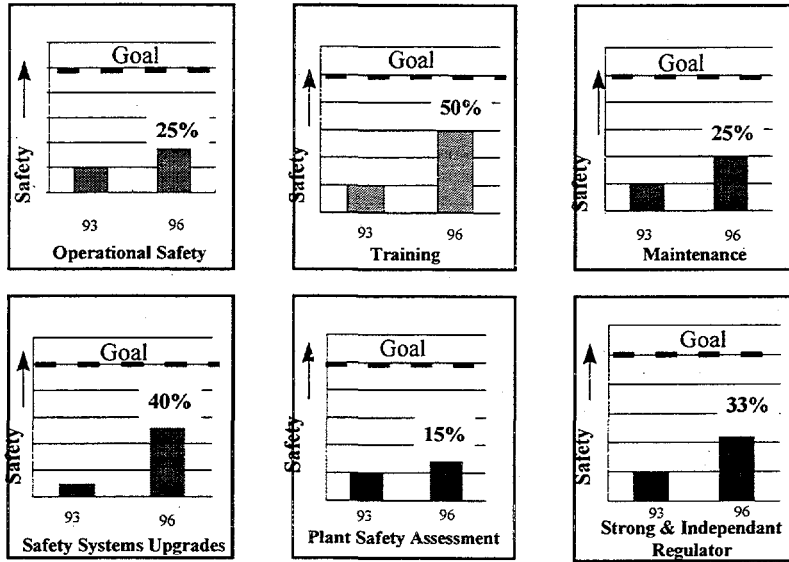


## **PERFORMANCE MEASURES**

- Program Progress - milestones
- Program Effectiveness - impact on safety

# Measuring Safety Improvements

## Soviet-Designed Reactor Safety



United States Department of Energy  
Office of Nuclear Energy, Science and Technology

December 30, 1996





## Addressing Safety Issues at Chernobyl: An Overview

**Laurin Dodd**  
**Pacific Northwest National Laboratory**

February 19, 1997



## Basis for DOE involvement at Chernobyl



- ◆ December 1995 memorandum of understanding signed by Ukraine and G-7 countries
- ◆ U.S. commitments based on that signing



## Challenges at Chornobyl

- ◆ **Socioeconomic impacts of plant closure**
  - ❖ **Slavutych economy depends upon Chornobyl nuclear power plant**
    - 1,200 workers affected by closure of Unit 1
    - high stress levels could affect safety
- ◆ **Decommissioning reactors**
- ◆ **Converting Chornobyl Unit 4 into an ecologically safe condition**

## **Fire Safety Upgrades at Chernobyl Nuclear Power Plant**

**February 19, 1997  
Mike Archdeacon  
Bechtel National, Inc.**

### **Chernobyl Nuclear Power Plant Operating Status**

Four Units at Chernobyl each capable of producing  
1000mw Electric.

At this time there is only ONE unit operating, Unit No. 3.

Unit No. 1 was supposedly closed down permanently in  
November 1996.

Unit No. 2 has not operated since the turbine hall fire in  
late 1991.

### **Chernobyl Nuclear Power Plant Operating Status (contd)**

Unit No. 3 is the only Unit currently producing power.

Unit No. 4 was the site of the tragic accident in 1986.

### **Chernobyl Nuclear Power Plant - Fire Protection Measures discussed with Plant Management**

- Fire Doors
- Fire Detection Equipment
- Penetration Sealant Materials
- Fire Retardant Cable Coating Materials
- Floor Coating Materials to Replace the Existing Plastic Floor Sheeting Material

**Chernobyl Nuclear Power Plant - Fire  
Protection Measures discussed with  
Plant Management (contd)**

- Structural Steel Fire Protective Coating Materials
- Support to the Plant Fire Brigade
- New Fire Suits
- Adjustable Hose Stream Nozzles

**FIRE HAZARDS ANALYSIS**

In addition to the following materials being supplied to the plant, Bechtel and Burns and Roe, working with the USDOE, PNNL, Brookhaven National Lab and other US industry experts, developed a FHA methodology document designed to allow the FSU nuclear plant personnel to evaluate their own plants.

This program is well under way and a series of training sessions with representatives from the plants, including Chernobyl, have already taken place here in Washington, D.C.

The next stage is for follow-on training programs to take place at two defined pilot plants, one in Russia and one in Ukraine.

## **FIRE DOORS**

Approximately 200 fire doors are being supplied.

Doors are being supplied by a Ukrainian manufacturer.

The doors were developed by a local manufacturer and certified to ISO standards.

The contract also allows for the production of the design documents and installation.

## **FIRE DOORS (contd)**

Design is in process.

The design process is the production of design documents which define the location of the replacement doors.

This process has been slowed down due to the loss of some of the original documents in the 1991 fire.

Production of the doors has commenced.

Delivery and installation to commence in the second quarter of 1997.

## **FIRE DETECTION EQUIPMENT**

Scope of supply discussed with the plant.

Qualified US suppliers certified to supply components to the Ukraine nuclear industry were evaluated.

Prices of US equipment evaluated and sample equipment sent for the plant to review.

The plant is presently working with its design agency to initiate the design process.

## **PENETRATION SEALANT MATERIAL**

Many penetrations are either in need of replacement or the penetration openings are not already sealed.

US suppliers were evaluated for their ability to provide the materials to the Ukraine nuclear industry.

New regulations were imposed on the certification of all materials in April 1996.

## **PENETRATION SEALANT MATERIAL (contd)**

The plant defined the quantities of material required and the schedule for the deliveries.

Training programs by the supplier are also included and scheduled.

Current status:

Initial deliveries are scheduled to arrive at the plant in March with subsequent deliveries every six months until September 1998.

## **FLOOR COATING MATERIALS**

The operating deck levels of the turbine halls in many of the FSU nuclear plants are covered with a very thick plastic sheet material.

This has already been replaced at the Leningrad NPP.

Presently trying to certify a US supplier to allow the use of their product in a Russian nuclear power plant.

Ukrainian representatives have, and will continue, to witness the Russian testing program.

## **FLOOR COATING MATERIALS (contd)**

The initial tests have been completed at the VNIPO Nr Moscow but the US products failed to pass the Russian tests.

Initially decided to also run tests in the Ukraine but as the US materials failed the Russian tests it was decided to delay the Ukraine testing program until confidence was restored in the US materials in Russia.

May be able to have the Ukrainian authorities evaluate the Russian tests and also allow use in the Ukraine.

## **Structural Steel Fire Protective Coating Materials**

Following the fire in Unit #2 turbine hall in late 1991, the Ukrainian authorities have dictated that a fire protective coating material be added to the structural steel roof trusses.

No US material is currently qualified to the Ukrainian standards.

### **Structural Steel Fire Protective Coating Materials (contd)**

A material from a German manufacturer has been certified for use, which has also already been applied to some Russian nuclear power plant structural steel.

Negotiations are currently under way with a Ukrainian contractor for the supply, design and supply of the protective material for Chernobyl Unit #3.

### **SUPPORT TO THE NUCLEAR POWER PLANT FIRE BRIGADE**

New fire suits.

Adjustable hose stream nozzles.

# Emergency Operating Instructions

Mike Daus  
Ciel Consultants, Inc.  
February 19, 1997

## **Emergency Operating Instructions (EOIs)**

- 6/96 Introduction to Symptom-Based EOIs
- 8/96 Technical Protocol, Writer's Guide  
& Training Plan Development
- 10/96 Preparation of Draft EOI Flowcharts
- 11/96 EOI Verification & Validation Plan
- 2/97 EOI Analysis Workshop

## EOI Development Technology Transfer at ChNPP

Approach	Benefit
Prepare guidelines and plans	Written instructions for ChNPP staff to follow and refer to after Ciel leaves ChNPP
Prepare templates and outlines	Models are available for ChNPP staff to use in developing own ChNPP EOI product
Prepare training handouts Deliver training on program activities	ChNPP procedure writers provided direct access to expertise
Translate all deliverables to Russian	ChNPP procedure writers can gain exposure to program activities
Translate ChNPP staff products to English	Permits review of intermediate products by Ciel experts
Review ChNPP program products and activities	ChNPP procedure writers receive timely feedback as program progresses

### 6/96 - Introduction to Symptom-Based EOIs

- Symptom-Based EOI Concepts
- History of Symptom-Based EOI Development in US
- Elements of a Symptom-Based EOI Program

**8/96 - Technical Protocol, Writer's Guide  
& Training Plan**

- Guidelines for Development of EOI Technical Protocol
- Writer's Guide Development Outline
- Operator EOI Training Plan Description

**10/96 - Preparation of Draft  
EOI Flowcharts**

- Training given on use of Canvas™ flowcharting software application
- Writer's guide concepts updated
- Technical protocols reviewed
- Five flowcharts drafted and reviewed
- EOI verification principles discussed

**10/96 - Preparation of Draft EOI  
Flowcharts (contd)**

- Techniques developed for tracking flowchart development issues
- Identified potential EOI support instruction needs
- Prepared a source list of EOI action levels
- Identified need for analytical support

**11/96 - EOI Verification & Validation Plan**

- Delivered presentations on how to conduct V&V programs
- Reviewed and provided comments on latest flowchart drafts
- Reviewed and provided comments on technical protocols and writer's guide

### **2/97 - EOI Analytical Workshop**

- Review latest flowchart drafts and associated technical protocols and writer's guides
- Apply engineering judgment to resolve values for EOI action levels
- Review and finalize draft EOI support instructions

### **2/97 - EOI Analytical Workshop (contd)**

- Finalize V&V procedures and plans
- Train on EOI validation scenario techniques
- Review EOI Operator Training Program

### **ChNPP EOI Status**

- EOI flowcharts and technical protocols in final draft
  - 1 Reactor Shutdown, draft 7
  - 2 Subcriticality, draft 7
  - 3.1 Heat Removal Sheet 1, draft 9
  - 3.2 Heat Removal Sheet 2, draft 6

### **ChNPP EOI Status (contd)**

- 4 Reactor Space, draft 7
  - 5 Accident Localization, draft 6
- EOI Support Instructions in flowchart format to be completed this week
  - Writer's Guide approved

### **ChNPP EOI Status (contd)**

- EOI Program document approved
- Verification Program drafted
- Validation Program drafted
- EOI Operator Training Program being drafted
- Conduct EOI verification, validation and operator training





## Chornobyl Unit 4 Shelter Projects Overview

February 19, 1997

Dennis K. Kreid

Pacific Northwest National Laboratory



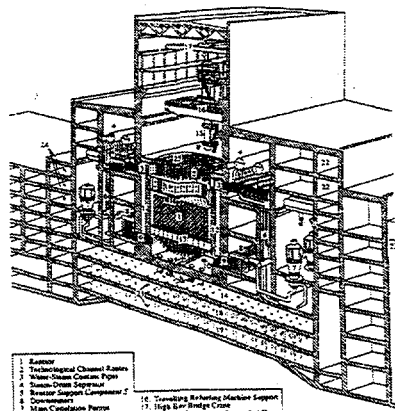
### Presentation Summary

- ◆ Shelter project overview
- ◆ Shelter safety needs/projects
- ◆ European Commission project results  
(John Woods, Stone & Webster)
- ◆ Short-term measures - John Woods
- ◆ Shelter working group activities



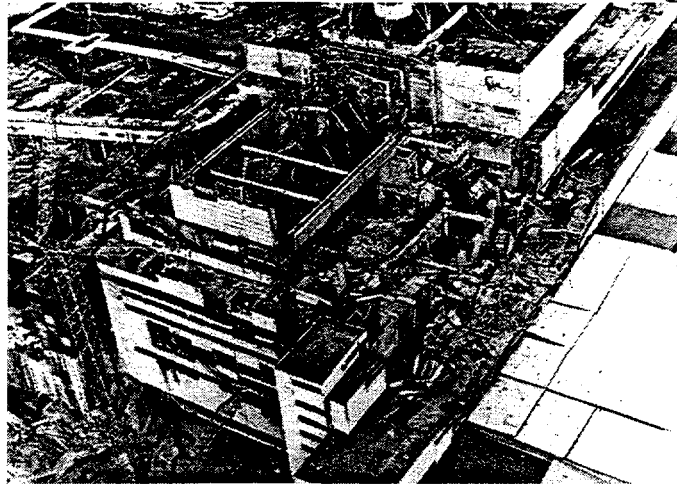
## Shelter Project Background and Overview

- ◆ **Objectives:** Support Ukraine and international efforts to improve safety of shelter operations and ultimate conversion to a safe configuration
- ◆ **Current shelter activities:**
  - ❖ Shelter equipment, immediate safety needs support
  - ❖ International project working group

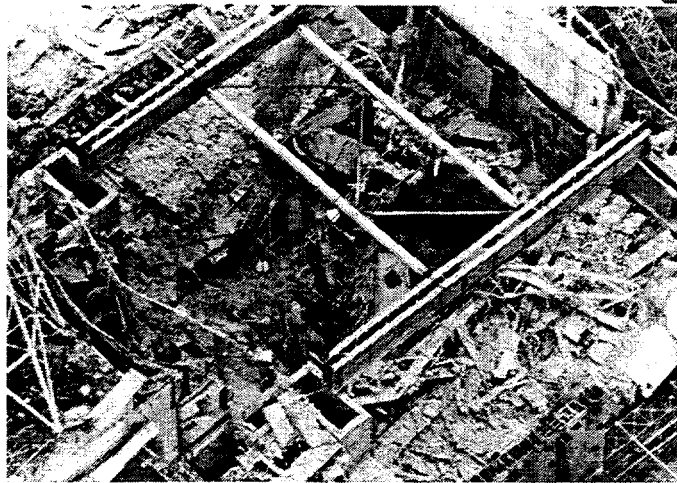


- |                                 |   |
|---------------------------------|---|
| 1. Access                       | 16. Transiting Refueling Machine Support  |
| 2. Technological Channel Piping | 17. High Rise Bridge Crane                |
| 3. Main Channel Control Valve   | 18. Pressure Suppression Pool - Out Floor |
| 4. Steam-Dross Separator        | 19. Pressure Suppression Pool - In Floor  |
| 5. Reactor Support Component 2  | 20. Service Distribution Header           |
| 6. Downcomer                    | 21. Drainage System                       |
| 7. Main Circulation Pump        | 22. Turbine Labyrinth Sealing             |
| 8. Control Distribution Header  | 23. Location of ECCS                      |
| 9. Water Control Panel          | 24. Emergency Channel Service Block       |
| 10. Spill-Resistant Edge        |   |
| 11. Upper Refueling Scaffold    |   |
| 12. Lower Refueling Scaffold    |   |
| 13. Lower Refueling Scaffold    |   |
| 14. Station Chamber Locomotive  |   |
| 15. Refueling Machine           |   |

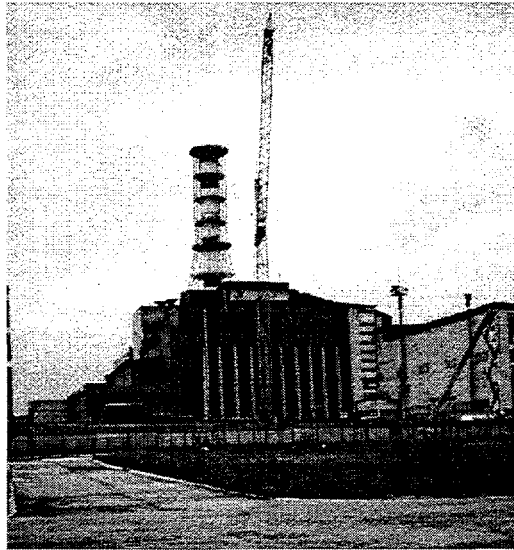
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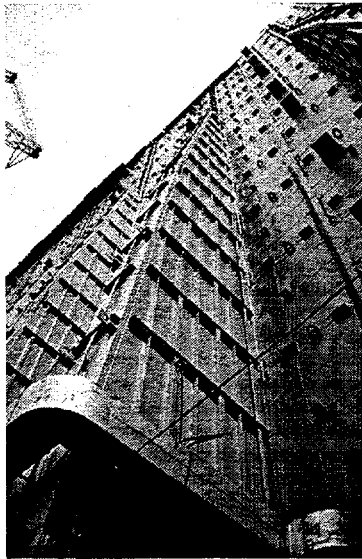
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CONTRACTOR INFORMATION EXCHANGE





### Chornobyl Shelter Safety Equipment Needs

- ◆ Initial shelter needs assessment - May 1996
- ◆ Major basic safety equipment needs readily apparent and beyond means of Chornobyl plant
- ◆ Four tasks subsequently authorized

Task	Auth Date	Detailed Assessment
Dose reduction	9/96	10/96
Nuclear (criticality) safety monitoring	11/96	11/96
Dust suppression	11/96	11/96
Industrial safety enhancements	12/96	12/96



## Chornobyl Shelter Safety Equipment Needs

- ◆ Tasks directed at near-term worker safety improvements
- ◆ Radiological safety improvements including training, for ongoing shelter maintenance and work efforts
- ◆ Industrial safety improvements including training, for ongoing shelter maintenance and work efforts
- ◆ Establish safety emphasis and build infrastructure for larger forthcoming tasks
- ◆ Establish improved physical conditions in shelter to safely support larger forthcoming tasks



## Chornobyl Shelter Safety Equipment Needs

### Dose Reduction

**Objective:** - Provide equipment, training and mentoring to improve worker radiological protection and infrastructure

**Deliverable:**

- Electronic dosimetry, dose-tracking software, portable survey instruments
- Radiation protection technician standards-based training
- Engineered controls and dose modeling software
- Excess calibration sources and rad clothing/respirators



## Chornobyl Shelter Safety Equipment Needs

Dose Reduction (continued)

Requested: - TLD systems, respirator cleaning/testing,  
additional training

Status: - Equipment deliveries initiated and extending  
through 9/97 for approved items



## Chornobyl Shelter Safety Equipment Needs

Nuclear (Criticality) Safety Monitoring

Objective: Install neutron monitoring in key fuel-containing  
locations to assess cause of observed  
transients, define mitigation required, if any,  
and ensure worker safety



## Chornobyl Shelter Safety Equipment Needs

### Nuclear (Criticality) Safety Monitoring (continued)

Deliverables: - Eight detector pods will be provided for monitoring of 6 key locations

- Record future event data analysis and definition of any mitigation measures if required (n flux, Cd ratio,  $\gamma$ , temp, humidity)
- Provide basis for long-term shelter neutron monitoring needs

Status - System delivery to shelter, July 1997



## Chornobyl Shelter Safety Equipment Needs

### Dust Suppression

Objective: Provide portable self-contained airless sprayers for decon solution and fixative application in shelter periphery access-ways and support areas for improved radiological conditions

Deliverables: 3 airless sprayer units

Requested: Steam-water vapor-vacuum surface cleaner



## Chornobyl Shelter Safety Equipment Needs

### Dust Suppression (continued)

**Status:** Sprayers being purchased

**Note:** Chornobyl funded efforts directed at emergency dust suppression; "EKOR" foam demonstration pending for application to severe dust conditions



## Chornobyl Shelter Safety Equipment Needs

### Industrial Safety Enhancements

**Objective:** Provide equipment to supply immediate improvements to worker industrial safety

**Deliverables:**

- Miscellaneous safety equipment (hard hats, respirators, ear plugs, low voltage lighting, ladders, first aid kits, etc.)
- Fall restraint and rescue gear and training
- Lightweight and reliable tooling for hanging existing cabling, personnel and ventilation accessways (drills, saws, jackhammers, compressors, and generators)



## Chornobyl Shelter Safety Equipment Needs

Industrial Safety Enhancements (continued)

Requested: Shelter communications

Status: Most items being purchased



## International/E.C. Shelter Project Task Descriptions

- ◆ E.C. shelter project objectives: Investigate alternatives to the Alliance "shelter-2" design and recommend alternative short- and long-term measures
- ◆ International shelter project working group objectives: Complete E.C. detailed cost and schedule estimates and identify early starts to support pledging for shelter



### Shelter Project Background

- ◆ International shelter competition, 1992-93
- ◆ E.U. funded Alliance shelter study, 9/94-7/95
- ◆ G-7/Ukraine Chernobyl closure MOU, 12/20/95
- ◆ U.S. safety equipment needs project, 4/96 - present
- ◆ E.C. short- and long-term measures project, 5/96-10/96
- ◆ International shelter project Working Group 1/27 - 4/97



### U.S. Industry Participants

- ◆ Stone & Webster
  - ❖ Edward Warman, U.S. Team Coordinator
- ◆ Bechtel
- ◆ Parsons
- ◆ SAIC
- ◆ Scientech



## E.C. Shelter Project Status

- ◆ Draft report delivered on schedule (10/31/96)
- ◆ Recommendation is composite of best ideas from alternatives (or scenarios) considered
- ◆ E.C. recommendations partially accepted by G-7/Ukraine at 12/17/96, G-7 meeting in Slavutych
- ◆ Working Group in progress to support May 1997 G-7 pledging conference



## Accepted E. C. Shelter Study Recommendations

Step 1: Implement short-term measures at minimum feasible dose

- ◆ Implement short-term measures (0<t<4 yr)
  - ❖ Stabilize structures to reduce collapse potential
  - ❖ Reduce consequences of collapse (dust control)
  - ❖ Improve nuclear (criticality) safety
  - ❖ Improve industrial safety
- ◆ Shield fuel-containing masses coincident with Step 1 measures



## Accepted E. C. Shelter Study Recommendations (continued)

### Step 2: Construct new shelter and partially deconstruct existing shelter

- ◆ Construct new shelter (1<t<8 yr)
  - ❖ Design and assemble new confinement shelter
  - ❖ Disassemble unstable parts of existing shelter
  - ❖ Maintain access to and monitoring of fuel-containing masses
  - ❖ Support development of removal technology for fuel-containing masses
- ◆ Ensures safe storage for up to 50 years
  - ❖ Longer storage possible by periodic upgrades
  - ❖ Decision to remove fuel-containing masses feasible at any time



## Other E. C. Shelter Study Recommendations, (Not Accepted)

### Step 3: Convert shelter to interim safe structure

- ◆ Entomb the shelter and reactor remains
  - ❖ Cement or earthen fill and entombment
  - ❖ Maintain access to fuel-containing masses as long as needed
  - ❖ Other future options may develop
- ◆ Options for long-term disposition of fuel-containing masses
  - ❖ Removal (total/partial)
  - ❖ Permanent in situ disposal
  - ❖ Decision/implementation possible any time



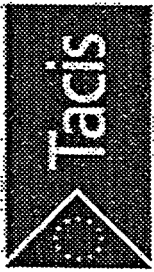
## Ukraine and Russian Participants

### Ukraine:

- ◆ Chernobyl nuclear power plant - Shelter Operations
- ◆ NIISK Construction Institute
- ◆ ISTC - Shelter Scientific Institute
- ◆ Ukraine Nuclear Regulatory Agency Technical Center

### Russia:

- ◆ Khlopin Radium Institute
- ◆ VNIPIET Institute
- ◆ Kurchatov Institute



Chernobyl Nuclear Power Plant

# *European Commission Project*

## *Results and Short Term Measures*



Battelle



Stone & Webster  
Jack Woods

14Feb97



## *Chernobyl Short & Long Term Measures Project - Background*

- **Following Kiev Competition - New Shelter**
- **Alliance Consortium - Feasibility Study**
- **Alliance Design Both Large & Expensive**
- **Tacis Project - Alternative Solutions**
- **Actions 1 & 3 - Safety Objectives**
- **Actions 2 & 4 - Short & Long Term Measures**



**Stone & Webster**  
Jack Woods

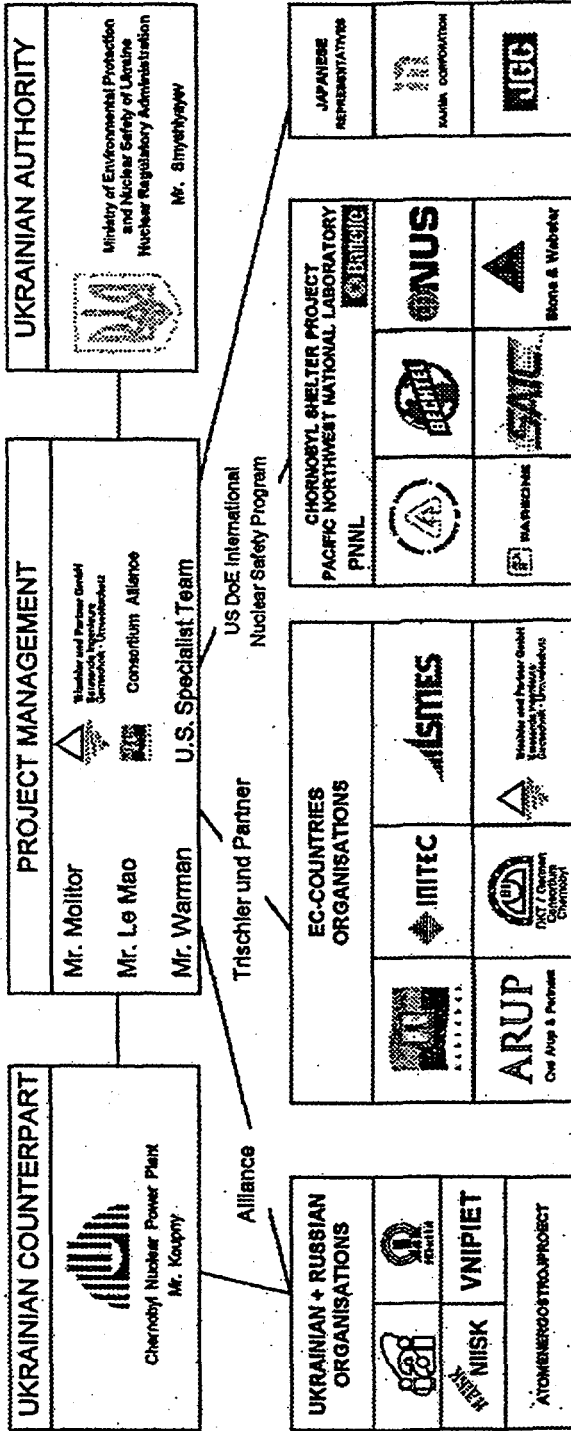
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The present report was worked out and reviewed for the EC Directorate IA for the Taxis project "Chernobyl Unit 4, Short and Long Term Measures, Actions 2 + 4 by an international group of experts coming from Ukrainian, Russian, European, American and Japanese firms and organizations. The review and working team and the project organization are presented on the chart.



- M.o.U.
- Moscow Summit
- G7 NSWG

EC Ukraine Protocol  
11 Sept. 1995



Final Report - 3/1/1998

Stone & Webster  
Jack Woods

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## *Project Description*

### *EC Tacis Project joined by US Expert Team*

#### *Focus:*

- Development of technically sound solution
- Cost Estimate - financially feasible budget

#### *Approach:*

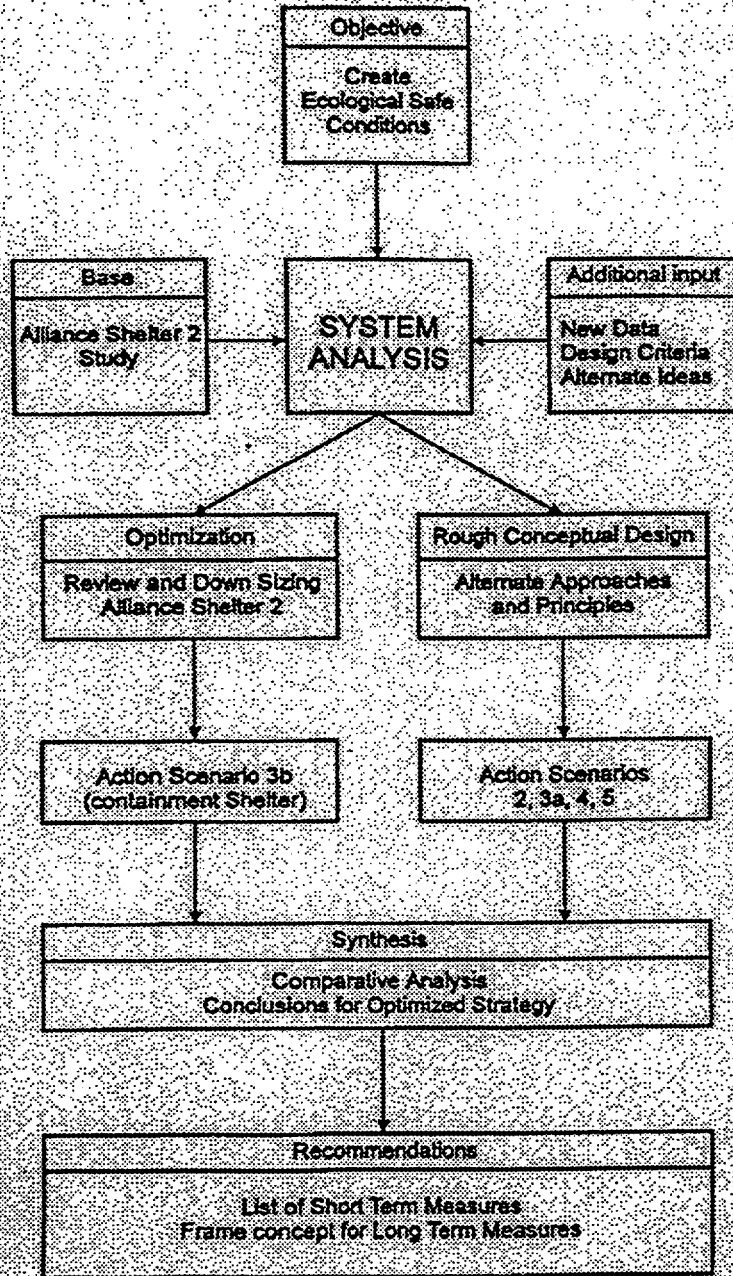
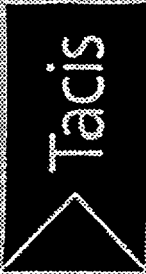
- Evaluated Five Scenarios/with subsets
- Developed Recommended Course of Action



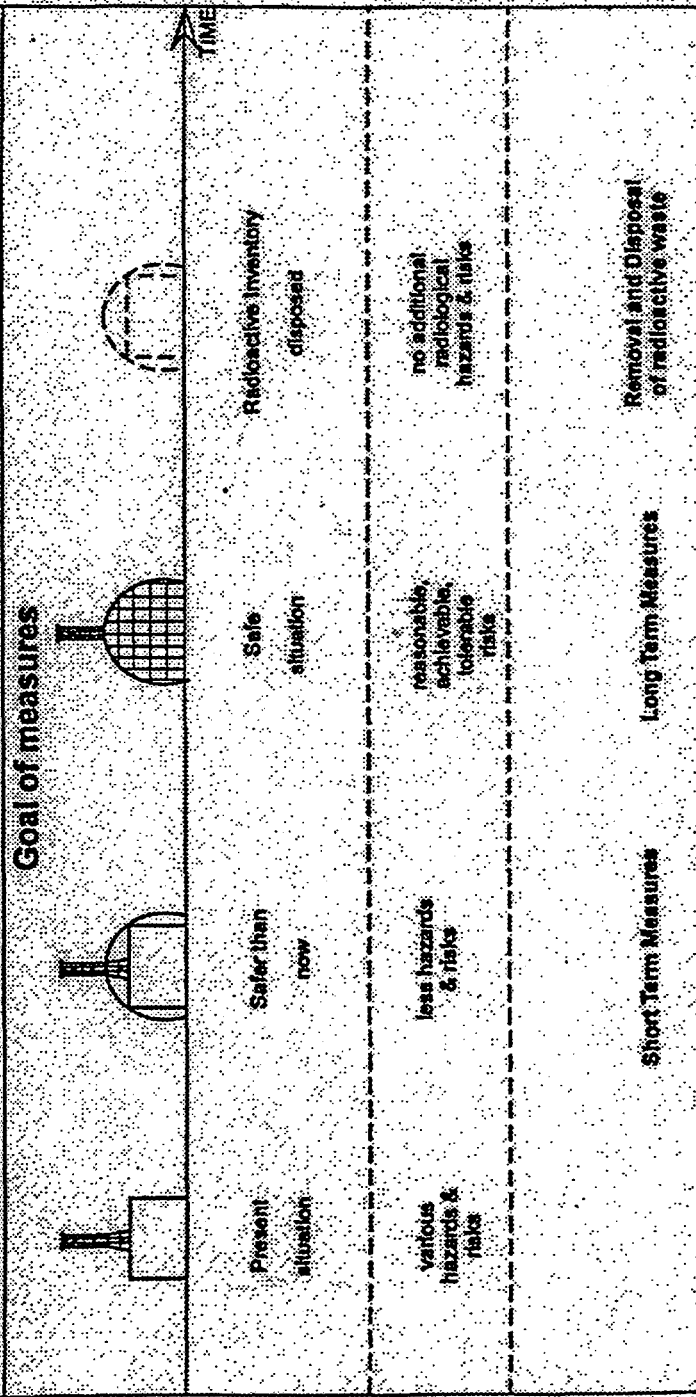
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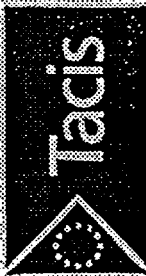
# Chernobyl-Unit 4 Short and Long Term Measures



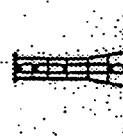


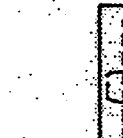


# Tacis Chernobyl-Unit 4 Short and Long Term Measures



△ Trechtler und Partner GmbH, 11766, Leipzig, sdr



# Chernobyl-Unit 4 Short and Long Term Measures

 Present situation	Phase 1 1997-2001	Phase 2.1 Shielding & Access	Phase 2.2 1998-2005 New Confinement and Partial Deconstruction	Phase 2.3 2005-2025 Partial Removal of Accessible FCM	Phase 3 Conversion into an Ecologically Safe Site (Deferred Removal)
	Phase 1 Short Term Measures <ul style="list-style-type: none"> <li>- Structural Stabilization</li> <li>- Monitoring</li> <li>- Nuclear Safety</li> <li>- Industrial and Environmental Safety</li> </ul>				
					
					
					
					

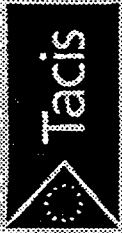
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# Chernobyl-Unit 4 Short and Long Term Measures



## Scenarios

 Baseline Scenario 1	 Action Scenario 2	 Action Scenario 3a	 Action Scenario 3b	 Action Scenario 4	 Action Scenario 5.1	 Action Scenario 5.2
Implemented Short Term Measures (see Scenario 2)						
Do nothing except continuing the present	Define and implement Short Term Measures. Continue active risk management as long term Measures	Build a small Shelter around existing Derris	Build a long lived shelter to contain and combine Chernobyls in case of collapse	Contain and confine with a long lived Earth Shelter	Shield, stabilize and contain with conventional materials and confine with a long lived Shelter	Shield, stabilize and contain with conventional material. Keep inventory in place. Proceed to removal if required.
Baseline for Comparison		Proceed to early removal	Proceed to removal when it is appropriate	Proceed to removal with access of heavy equipment if required.	Proceed to removal when it is appropriate	

Trisehler und Partner GmbH (1995), Scenario 2

Trisehler und Partner GmbH (1994), Prognose



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14Feb97



***Recommended Course of Action***

**Phase 1: Short Term Measures (17 )**

**Task 1.1 Reduce Collapse Probability**

**Task 1.2 Reduce Collapse Consequences**

**Task 1.3 Increase Nuclear Safety**

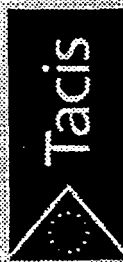
**Task 1.4 Increase Industrial Safety**



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Jack Woods**

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# Chernobyl-Unit 4 Short and Long Term Measures



## REDUCE RISK TO WORKERS, THE PUBLIC AND THE ENVIRONMENT

### REDUCE ACCIDENTAL COLLAPSE POTENTIAL (STABILIZATION)

- N WEST WALL STABILIZATION
  - INTERNAL STIFFENING
  - EXTERNAL SUPPORT
- N CEILING SELECTED ROOMS
- N DEGRADATION BLOCK STABILIZATION (RAMMOTH BEAM)
- N VENTILATION CHIMNEY SUPPORT
  - INTERNAL
  - EXTERNAL
- N ROOF STABILIZATION
  - INTERNAL STIFFENING
  - EXTERNAL SUPPORT
- N STRUCTURAL INVESTIGATION
- N GEOTECHNICAL INVESTIGATION
- N SEISMIC CHARACTERIZATION
- D PARTIAL DECONSTRUCTION
  - LIGHTNING PROOF
  - TURBINE HALL
  - D NEW ROOF

### REDUCE ACCIDENTAL RELEASE CONSEQUENCES

- N EMERGENCY PLAN
- N DUST REDUCTION PRIORITIES (PASSIVE)
- N COMPENSMENT
  - SPRAY SYSTEMS (ACTIVE)
  - SHELTER OPTIONS
- D SELECTED REMOVAL OR CONSOLIDATION OF SOURCES

### FUEL CONTAINING MATERIAL RADIOACTIVE MATERIAL MANAGEMENT

- N CRITICALITY CONTROL
  - MONITORING
  - MITIGATING MEASURES
- N CONTAMINATED WATER MANAGEMENT
  - CHARACTERIZATION
  - REMOVAL/TREATMENT (STORAGE) DISPOSAL
- N FUEL CONTAINING MATERIAL CHARACTERIZATION
- N RADIOACTIVE MATERIAL CHARACTERIZATION
- N PHYSICAL ACCESS
- N DEVELOP REMOVAL/DISPOSITION STRATEGIES
- N RADIOACTIVE MATERIAL CONTROL
  - D REMOVE FUEL CONTAINING MATERIAL TO SAFE STORAGE
  - D RADIOACTIVE MATERIAL REMOVAL/TREATMENT/STORAGE/DISPOSITION

### TRANSFORMATION TO SAFE OPERATING CONDITION

- N RADIOLOGICAL CONTROL PROGRAM
  - PROTECTIVE EQUIPMENT
  - DOCUMENTATION
  - LABORATORY EQUIPMENT
  - SMALL DOSE
  - RADIATION MONITORING
  - CONTROL
- N CONTAMINATION CONTROL
  - IDENTIFICATION OF CONTAMINATED DATABASE
  - N IMPLEMENTATION OF INTEGRATED DATABASE
  - N ACCIDENTAL SAFETY PROGRAM (PANEL LIGHTING incl)
- D ENVIRONMENTAL CONTROL
  - MONITORING
  - ACTIVE VENTILATION
  - GROUNDWATER PROTECTION

SHORT TERM PRIORITY: N NECESSARY/URGENT D DESIRABLE \* U.S. DONATION

Trischer und Partner GmbH 11/96, Priority.ppt



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Jack Woods

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# *Recommended Course of Action*

## **Phase 2: Preparation for Long Term Conversion**

**Task 2.1 Shielding & Controlled Access**

**Task 2.2 New Confinement & Removal of Unstable Parts**

**Task 2.3 FCM Removal Strategies**



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Jack Woods**

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# *Recommended Course of Action*

## **Phase 3: Conversion to a Safe Site**

**Task 3.1 Convert the site into a safe structure**

**Task 3.2 Control and maintain the safe structure until removal**

**Task 3.3 Removal of remaining FCM when ready**



**Stone & Webster  
Jack Woods**

14Feb97

# Scenario Cost Estimates

Scenario	Estimate (Million\$) Total
1. Baseline (Continue status quo)	No Est. Req'd
2. Short Term Measures	\$180
3.a Light Weight Confinement Structure	\$419
3.b Revised Alliance Containment	Not Calculated
4. Earth Shelter	\$113
5.1.a Cementitious Fill of Ukritye	\$ 66
5.1.b Cementitious Fill + Bridge / Roof Truss	\$185
5.1.L Cementitious Fill + Bridge Confinement	\$244
5.2 Concrete Monolith	\$ 63
	\$293
	\$246
	\$365
	\$424
	\$243

**Note:** Scenario 2 (\$180) is also part of scenarios 3, 4, & 5, so the cost must be added to determine the Total Estimate



**Stone & Webster**  
Jack Woods

14Feb97





**Chornobyl Reactor Deactivation, Decontamination,  
and Decommissioning Project  
-- Concept, Status, and Path Forward --**

February 19, 1997

Thomas W. Wood

Pacific Northwest National Laboratory



**Objective**

Support the orderly deactivation, decontamination, and decommissioning (D, D&D) of Units 1, 2, and 3 at Chornobyl, consistent with timely reactor shutdown, regional economic stability, and operating safety. Support the development of a sound technical and regulatory basis for RBMK D, D&D activities on an international basis. Foster development of capability for D, D&D planning and implementation within the Chornobyl Center and Chornobyl Nuclear Power Plant (ChNPP).



### Project Status

- ◆ **Funded at \$1.0 M in FY-97 for three initial tasks**
  - ❖ Transfer awareness of U.S. D, D&D technologies and process to senior ChNPP and NRA management
  - ❖ Conduct survey of Unit 1 readiness and resources for deactivation
  - ❖ Clarify risk reduction benefits of deactivation steps (DOS)
- ◆ **Recent request from ChNPP to consider more substantive and extensive project scope**



### Project Concept (Initial)

- ◆ **Transfer U.S. technology in a three step process**
  - ❖ Familiarization of D, D&D technology in use at Hanford, other DOE sites, and commercial reactor sites
  - ❖ Selection of promising technology for ChNPP
  - ❖ On-site testing/demonstrations and training at ChNPP
- ◆ **Maximize local content and economic benefit of D, D&D activity**
  - ❖ Define regional D, D&D skills early to allow ChNPP labor force planning
  - ❖ Provide U.S. technology/supplies as training resources



## Background

- ◆ D, D&D can be a complex and costly process
- ◆ There are significant nuclear safety issues for shut down RBMK reactors
- ◆ The regulatory framework for D, D&D is just emerging in Ukraine
- ◆ There are both economic and safety incentives to proceed soon with D, D&D
- ◆ Efforts to date (AEA Technology study) represent a prescription for the outcome - not a plan to realize it



## ChNPP Proposed Deliverables for Joint Project

- ◆ Requirements for comprehensive engineering (radiological and structural) survey of Unit 1
- ◆ Performance and reporting of the comprehensive engineering survey
- ◆ Development of requirements for a Safety Analysis Report (SAR) for the D&D phase



## ChNPP Proposed Deliverables for Joint Project (continued)

- ◆ Development of the requirements for a detailed decommissioning plan for ChNPP. These requirements would be generic and apply to all three units.
- ◆ Development of the SAR and detailed decommissioning work plan described above, in sufficient detail to support the ChNPP license application for the D, D&D phase.
- ◆ Performance of background research on several issues relevant to these documents, including specifically a study of alternative techniques for cooling pond decommissioning.



## Proposed Path Forward

- ◆ FY-97
  - ❖ Complete three items from ChNPP proposal under existing funding
    - Requirements for Engineering Survey
    - Requirements for SAR
    - Options definition for cooling pond
  - ❖ Transfer key capabilities (software, data) to Center
  - ❖ Initiate work on other items to extent funding is available
- ◆ FY-98/99
  - ❖ Complete remaining three items in joint project



### Protocol Agreement

- ◆ The existing heat plant cannot meet the total site demand; new plant is 25% complete.
- ◆ The thermal energy requirements of D&D efforts will be above the current demand.
- ◆ PNNL and Chernobyl technical specialists will share information and analysis results.





**Chornobyl Center for Nuclear Safety, Radioactive  
Waste and Radioecology  
-- U.S. Perspective --**

February 19, 1997

Roger G. Anderson

Pacific Northwest National Laboratory



**Original Concept**

- ◆ Develop the institutional capacity, indigenous to Ukraine, to provide scientific support to the Ukrainian nuclear industry



## Objectives

Through international cooperation,

- ◆ Develop sustainable operational safety programs that support Ukrainian nuclear power plants
- ◆ Help develop and maintain in-country expertise in nuclear sciences
- ◆ Address decontamination and decommissioning, spent fuel, and waste management issues at Chernobyl and elsewhere in Ukraine



## Objectives (contd)

Through international cooperation,

- ◆ Provide a means for international cooperation in addressing environmental, ecological, and health issues for those areas affected by the accident
- ◆ Help to mitigate the socioeconomic impacts associated with the shutdown of the Chernobyl nuclear power plant



## Development Milestones

May 1995	Statement of Intentions by President Kuchma and President Clinton
June-August 1995	Preliminary Joint U.S.-Ukraine Development Plan
September 1995	Chornobyl Center included in G-7 Action Plan
April 1996	Ukrainian Presidential Decree Establishing Center -- Dr. Valery Glygalo named Coordinating Director
April 1996	U.S.-Ukraine Memorandum of Understanding
January 1997	Protocol to Establish Chornobyl Center Subsidiary (Slavutych Laboratory for International Research and Technology) and Initial Facilities and Staffing -- Mr. Anatoly Nossovsky named Center Deputy



## International Participation

- ◆ Canada
  - ❖ joint projects initiated
- ◆ France & Germany
  - ❖ joint projects initiated, involving Russia and Belarus
- ◆ Italy
  - ❖ financial support announced
- ◆ United Kingdom
  - ❖ potential interests being explored
- ◆ Japan
  - ❖ potential interests being explored
- ◆ Other countries
  - ❖ expressions of interest



## U.S. Assistance

**Under the direction of the U.S. Department of Energy, Office of Nuclear Energy, Science and Technology, the Chernobyl Center Project includes**

- ◆ Management Support
- ◆ Infrastructure Development
- ◆ Joint Projects



## Management Support

- ◆ Planning for Center Development
- ◆ Slavutych Staff Liaison
- ◆ Training
- ◆ Outreach / Integration



## Infrastructure Support

- ◆ **Telecommunications System**
  - ❖ Satellite-based voice, fax, and high-speed data transmission
  - ❖ Videoconferencing being planned
- ◆ **Nuclear Data Facility**
  - ❖ Capability to acquire and process basic nuclear data for use in safety and radiological assessments
  - ❖ Access to specific datasets and information at PNNL and elsewhere
- ◆ **Office Facilities and Equipment**



## Joint Technical Projects

- ◆ **Hazards Analysis of Unit 3/Shelter**
- ◆ **Spent Fuel Management Plan for Ukraine**
- ◆ **Chornobyl D&D Planning**
- ◆ **Modeling Assessments**
- ◆ **Robotics Technologies Assessment**



### Next Steps

- ◆ **Facilities Renovations**
  - ❖ Feasibility review
  - ❖ Recommendations
- ◆ **Staffing**
  - ❖ Transfers from Ukrainian government
  - ❖ Transfers from the Chernobyl nuclear power plant



### Next Steps (contd)

- ◆ **Management Training**
  - ❖ Senior management training—R&D organization management
  - ❖ Project management
  - ❖ Administrative internships
  - ❖ English language training
- ◆ **International Coordination and Integration**
  - ❖ Informal information-sharing
  - ❖ Formal participation through bilateral agreements with Ukraine



### Future Activities

- ◆ Operational Safety and Radiological Protection Training
- ◆ Shelter Monitoring, Stabilization, and Cleanup
- ◆ Chernobyl Closure and Decommissioning
- ◆ Development, Demonstration, and Use of New Technologies



### Suggestions for Complementary Projects and Infrastructure: Near-Term Needs

- ◆ Identify and implement scientific support roles for the Chernobyl Center in Shelter/Unit 4 Short-Term Measures Program
- ◆ Engage the Chernobyl Center in data acquisition and characterization tasks to build information management resources and credibility
- ◆ Create opportunities for Chernobyl Center participation in commercial tenders and technology development ventures



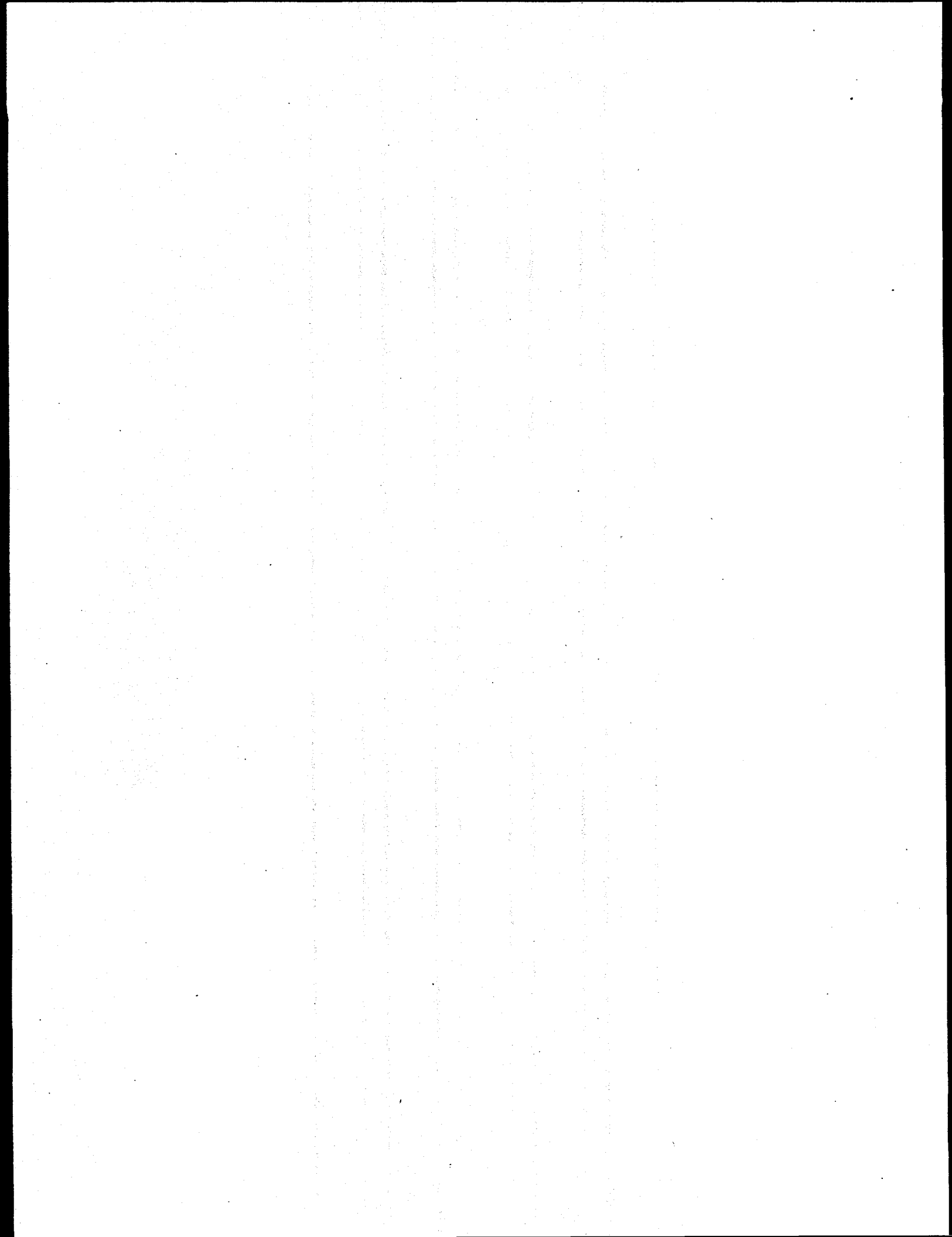
### Suggestions for Complementary Projects and Infrastructure: Near-Term Needs (contd)

- ◆ Establish twinning relationships to enhance business management and joint technical development capabilities
- ◆ Participate in funding facility renovations and equipping of offices and laboratories
- ◆ Consider participation in development of a multi-purpose technology testing and demonstration facility

## **Appendix D**

### **Enhancing Technology Transfer - Handout Papers**

- **Enhancing Technology Transfer in DOE's International Reactor  
Safety Projects ..... D.1**
- **Safety System Augmentation at Russian Nuclear Power Plants ..... D.13**



# **Enhancing Technology Transfer in DOE's International Reactor Safety Projects**

## **Background**

The DOE has a unique opportunity to influence the safety of nuclear power plants in Russia, Ukraine and Eastern Europe. In determining the best use of funding available for upgrading plant safety, it is vital to recognize that the support activity to these countries has finite duration and that the available funds are very limited in comparison to the funding needed to make these plants approach western safety standards. To be effective, the DOE efforts must help the countries help themselves. When U.S. support ends, the DOE must leave behind a safety culture and a safety infrastructure. The countries must be capable of sustaining the enhancements in safety that have been made and have the motivation and capability to extend these enhancements to other plants. This paper discusses the transfer of technology in these projects.

## **Technology Transfer**

For the purposes of this white paper, technology transfer is defined as the provision of U.S. technology that enables the recipient to better perform a safety related function. Technology transfer can take a number of forms, as indicated in Table 1.

The mechanisms identified range from the informal and least structured, Information Exchange, to the most formal and structured, Joint Venture. The appropriate mechanisms of technology transfer will depend on the project. For example, it would not be feasible to develop an in-country capability to manufacture every type of safety component for the plants in that country. Access to a supply of components and the knowledge of how to develop specifications and make procurements are essential, however.

Some types of technology transfer are appropriate for every project. At a minimum, a project must assure information exchange, often in the form of training.

**Table 1. Technology Transfer Mechanisms**

<u>Mechanism</u>	<u>Definition</u>	<u>Examples</u>	<u>Benefits</u>
Information Exchange	Transfer of technical know how through publications or technical discussions.	Training courses, workshops, participation in technical meetings.	Educates personnel. Develops peer relationships between countries.
Joint Project	Team effort of U.S. and host country staff	Fully integrated team performing plant PSA	Enhanced on-the-job training, mentoring
Personnel Exchange	Temporary assignment of personnel with intent of transferring or receiving knowledge	Assignment of host country NPP operating staff to U.S. plant.	Training within a realistic environment. Transfer of safety culture
Capability Transfer	Transfer of a complete ability to produce an item or perform a safety related function.	Cooperative projects. Providing training techniques. Providing facilities.	In-country ability to produce items or perform safety related functions.
Licensing	Transfer of the ability to produce an item by charging fees for the use of intellectual property.	Russian company licensed by Promatec to produce and sell Promatec products.	In-country ability to produce items. Licensor willing to trade intellectual property for fee.
Joint Venture	Contractual arrangement to produce items or perform services.	WESTEK in Russia. WESTRON in Ukraine. GCR in Bulgaria.	In-country ability to produce goods or services. Potential for profits.

### **Incorporating Technology Transfer into Safety Upgrade Projects**

Technology transfer is introduced into a project at the planning stage. The extent to which technology transfer will be included can depend on the mind set of the planners. The planner should not only be thinking, "How do we provide a safety grade DC power supply system to Kola NPP?" but also, "How do we provide a Russian capability to improve DC power supply in their NPPs?"

For the selection of new programs, projects are evaluated against four criteria: Impact on Safety, Cost Effectiveness, Sustainability, and Host Country Commitment. The third criterion, Sustainability, is explicitly included to assure that project planners are considering technology transfer. "This criterion is important, not only to help select projects that build infrastructure, but also to assure that each project considers the best way to transfer technology to the host country." The benefits of technology transfer also appear implicitly in the other three evaluation criteria. For example, the most cost-effective projects are ones that provide a capability to the host country to make its own upgrades. In that manner the U.S. funds that supported an upgrade at one reactor are leveraged into similar safety improvements at other reactors.

## Technology Transfer in Different Technology Areas

The types of technology transfer that are appropriate vary with the nature of the project. Table 1 provides a generic categorization of modes of technology transfer. In the following sections, brief comments are provided about the ways in which technology transfer is occurring in each technology area (the Operational Safety area has been subdivided because of the diversity of project types). Some general examples are provided regarding how technology transfer could be improved.

### Emergency Operating Instructions

The support that the U.S. has provided associated with symptom based EOIs has been in the form of *Information Exchange* through use of working group meetings and workshops and *Capability Transfer* through the transfer of computer hardware. The extent of technology transfer in these projects is substantial. The host countries have received training that allows them to generate their own EOIs.

### Training

Training is by its nature *Information Exchange*. Technology transfer has occurred not only in the transfer of safety knowledge in technical areas to improve plant safety but also in the form of *Capability Transfer* by the transfer of training techniques and the establishment of training facilities in the host countries. *Personnel Exchange* can also be used to assist in the transfer of training techniques. This approach assures the capability of the countries to sustain and extend their training programs.

### Simulators

The simulator projects directly involve *Capability Transfer* in that the host country is provided with nuclear power plant simulation hardware and software that can be used for operator training and validation of Emergency Operating Instructions (EOIs). *Information Exchange* is provided in the form of training in the use and maintenance of the simulator. On one simulator project *Personnel Exchange* was a dominant means of technology transfer. On that project Ukrainian engineers spent twelve weeks at the U.S. simulator vendor to learn how to design and produce simulator computer models. These engineers will later become the core of the software modeling staff for the development of two full-scope simulators in the Ukraine. Another important technology transfer mechanism in the simulator area is associated with *Joint Ventures*. Most of the simulator projects are joint efforts that include both U.S. DOE funded and NPP funded contracts. In addition, many of the U.S. DOE funded activities are with joint U.S./Russian companies.

### Maintenance and Operational Practices

*Information Exchange*, *Personnel Exchange*, and *Capability Transfer* are the likely forms of technology transfer in this area. Centers of excellence, such as maintenance centers, are excellent vehicles to use

for training personnel and providing a sustaining resource of expertise that can be drawn upon by the different NPPs. *Licensing* for the use of proprietary non-destructive examination equipment is a possibility in this area, as well as the establishment of *Joint Ventures*.

### Plant Safety

The mechanisms for technology transfer in this area are *Information Exchanges*, *Joint Projects*, *Personnel Exchanges*, and *Capability Transfer*. *Information Exchange* and *Capability Transfer* activities include providing U.S. developed software, computer hardware, analysis methodologies and techniques, and training in the use and implementation of all of these products. In addition the program will sponsor in conjunction with other national and international organizations, such as the IAEA, topical meeting and workshops. The program is providing assistance to a number of in-depth safety assessment *Joint Projects* at selected NPPs in Russia and Ukraine. Lastly, the program will sponsor a limited number of *Personnel Exchanges* involving the short term appointments of host country specialists at U.S. Laboratories to work on focused scope safety analysis projects.

### Regulatory and Legislative

This area is largely limited to *Information Exchange* in the forms of training or the exchange of regulatory documents. Nuclear regulatory culture has also been positively affected through bilateral *Personnel Exchange*.

### Fuel Cycle Safety

The modes of technology transfer associated with this area depend on the extent to which the scope is expanded beyond dry cask storage. Within the scope of dry cask storage of spent fuel, the mode of transfer has been limited to *Capability Transfer* in that access has been provided to a U.S. vendor of casks. The capability could be extended to include an in-country capability to produce dry casks for other NPPs. In this event, *Licensing* and *Joint Venture* could be considered as viable modes of technology transfer.

### Engineering and Technology Safety

Of all of the technology areas, Engineering and Technology Safety is the one that probably has the greatest potential for enhancing technology transfer. Because the Engineering and Technology Safety projects typically involve the transfer of a piece of safety equipment that improves the safety of a specific plant, the benefit may be limited to that one plant unless a mechanism has been developed to extend that benefit to additional plants in that class. Furthermore, consideration should be given to the industrial infrastructure required to support hardware upgrades. Components will fail and have to be replaced. If the upgrade is to be extended to other plants, the most cost effective means could be an

in-country manufacturing capability. Training in the use and maintenance of hardware is also essential to obtain the intended safety benefit. Each of the technology transfer mechanisms identified in Table 1 can potentially be used for this purpose.

Some of the keys to the successful transfer of technology in past projects that have been noted are:

- On-site project management
- Majority of technical work performed on-site
- Assignment of management roles to utility staff
- Periodic critical review of all staff work to provide early feedback
- Work performed to written task plans and procedures
- Training of in-country consultants as well as utility staff
- Mentoring staff to allow them to become experts
- Highly qualified partners
- A market/economic situation capable of sustaining the transferred capability.

With the exception of activities performed in the Regulatory and Legislative area, the focus of most projects is on the regulated industry rather than on the regulatory agency. However, it is important to recognize that the success of every project depends on acceptance by the regulator. In addition, the regulator can have a strong effect on the sustainability of the project and the extension of an upgrade at one plant to other plants. Thus, it is necessary to consider the potential for upgrading the capability of the regulator through technology transfer as well as the utility, consultant, or supplier.

### **Process**

The following approach was proposed for reviewing and potentially upgrading the treatment of technology transfer in these projects. At the Contractor Information Meeting on May 21, 1996, an ad hoc working group was established to develop means to improve the transfer of technology in DOE's safety upgrade projects. As a first step in this initiative, the ad hoc working group assisted in the development of this paper. With this guidance, the program area integrators were requested to review technology transfer in their programs. The reports of the reviews performed by the technology integrators have been appended to this paper.

## Appendix A. Review of Technology Transfer Activities in the International Nuclear Safety Program

### A.1 Operational Safety

#### A.1.1 Emergency Operating Instructions

The support that the U.S. has provided associated with symptom based EOIs has been in the form of *Information Exchange* through use of working group meetings and workshops and *Capability Transfer* through the through the transfer of computer hardware. The extent of technology transfer in these projects is substantial. The host countries have received training that allows them to generate their own EOIs.

#### A.1.2 Training

Training programs are by their nature *Information Exchange*. The training staff at plants have been instructed in the Systematic Approach Training and have developed the capability to develop program modules for use at their plants.

#### A.1.3 Simulators

All of the simulator projects involve *Capability Transfer* and *Information Exchange*. The NPP obtains a valuable training aid and training in the use of the equipment. Projects of this type include: Balakova Simulator Maintenance Course and Tools, Zaporizhzhzha Simulator Maintenance Course and Tools, Slovakia Plant Simulator Upgrade, Engineering Training Center and Trnava Training Center Simulator Upgrade.

In a number of projects, the capability to design and manufacture simulators has also been transferred to an in-country partner in the form of a *Joint Venture*. Projects of this type have been undertaken as: Kola VVER-440/213 Full-Scope Simulator, Balakova Analytical Simulator, Novovoronezh 440/230 Analytical Simulator, Kalinin VVER 1000/338 Full-Scope Simulator, South Ukraine Unit 3 Simulator, Rivne Simulator, South Ukraine Unit 1 Simulator, and Chornobyl Analytical Simulator.

*Personnel Exchange* occurred within the Khmelnytsky VVER 1000 Full Scope Simulator project through the extended assignment of personnel to a U.S. simulator design and company.

#### A.1.4 Maintenance and Operational Practices

*Information Exchange* and *Capability Exchange* have been the principal modes of technology transfer in this area. Ultrasonic test equipment and training in the use of this equipment have been provided to Kursk.

## A.2 Engineering and Technology Safety

### A.2.1 Fire Safety

The primary goal of the Fire Safety Upgrade program is to decrease the risk that a fire at an NPP in one of the host countries could result in the inability to safely shut down the plant, fuel damage and a release of radioactive material to the environment. Although the program has ancillary humanitarian benefit of protecting the lives of fire fighters and the economic benefit of reduced fire loss, the rationale for the selection of projects to support is based only on the ability to reduce the risk of severe accidents involving release of radioactive material. There are two approaches being taken to accomplish this objective.

The first approach involves the provision of basic fire protection materials, such as: fireman suits, hand-held extinguishers, hose nozzles, self-contained breathing apparatus, fire detectors, penetration sealant material, and fire doors. A fire protection program must begin with the basics of prevention, detection and suppression. Until the basic capabilities of fire protection are established, it does not make sense to look at the details of assuring safe shutdown in a fire.

Fire prevention has not been an area of major emphasis in the tasks undertaken to date. This is an area where the potential exists to make major improvements but the willingness to undertake these improvements requires changes in safety culture. Typically, host country NPPs do not have effective programs to control the use of combustible materials, the storage of transient combustible materials, or the availability of ignition sources. Cigarette smoking is even allowed in the control room of NPPs, an area with the potential for extreme fire-related consequences. *Information Exchange* is the principal method for providing technology transfer in this area. Fire Hazards Analysis Training Courses are being provided for NPP engineers and for executives in Russia and Ukraine. Although the focus of these courses is primarily on the methods of fire hazards analysis, the elements of fire protection are also stressed. As part of these courses, the participants visit U.S. NPPs and have an opportunity to see how fire protection is implemented in these plants. The first of these courses was provided in 1995. Four additional courses will be presented in December 1996, January 1997, and February 1997. Training in fire protection has also been provided by the U.S. Nuclear Regulatory Commission to regulators and plant staff.

In the area of fire detection, the DOE has primarily provided western equipment to the host country NPPs. Technology transfer has been limited to *Information Exchange* in the training of the plant staff in the use of the equipment.

The third area of fire protection is suppression. Host country NPPs rely more heavily on fire brigades in response to fires than on automatic suppression devices, as in western NPPs. Much of the equipment provided supports the capability of the fire brigades, such as firemen's suits, self-contained breathing apparatus, hose nozzles and fire extinguishers. Much of this equipment has been provided by U.S. suppliers without significant technology transfer or effort to support local industries. There are,

however, a number of examples of *Capability Transfer* where technology transfer is occurring. At Zaporizhzhya, indigenous suppliers of self-contained breathing apparatus, fire extinguishers, and fire doors are being supported by the program. In the case of the fire doors provided by Asken Company, significant upgrading of the indigenous product has occurred because of modifications required to satisfy international standards. These doors are also being provided to Chornobyl NPP. Similarly, in Russia the Atomremmash Company in the Kursk Region is providing fire doors for Smolensk NPP. Although U.S. technology is not necessarily transferred in all of these cases, international standards or their equivalent are being imposed on the acquisition and installation of this equipment.

In addition to the provision of basic fire protection equipment, the DOE is providing *Capability Transfer* to Russia and Ukraine to analyze plants to assure that they can be shut down safely in a fire. The Reactor Core Protection Evaluation Methodology for Fire in Soviet-Designed Nuclear Power Plants documents the experience obtained by U.S. plants over the last twenty years in the performing fire hazards analyses. It is planned not only to provide the Methodology to the host countries but also to work with them in *Joint Projects* to perform safe shutdown analyses for pilot plants. Finally, *Information Exchange* is being used to educate plant staff on the application of fire hazards analysis techniques and to assist decision-makers in Russia and Ukraine to determine how the Methodology can be adapted as a standard practice in their countries. This training includes discussions with U.S. NRC staff, U.S. industry representatives, and visits to U.S. NPPs.

#### **A.2.2 Confinement Isolation Upgrades**

Confinement related projects have been performed at the Kola Unit 2 NPP as a pilot plant for VVER 440/230 upgrades. The sealing of leaks in the confinement structure has involved the application of materials developed for other purposes in the U.S. to confinement sealing. The U.S. based Promatec Company has developed a partnership with a Russian agent for the purpose of marketing projects and applying Promatec products in other NPPs. Indeed, Promatec has been successful in obtaining projects with a number of host country NPPs based on the successful application of sealing and fire protection materials in DOE sponsored projects.

Eleven isolation valves have been provided to Kola Unit 2. Although there was no direct transfer of U.S. technology in the purchase of these valves, a valve technology project has been initiated in which Burns and Roe is working with Russian and U.S. valve manufacturers to determine appropriate technology transfer opportunities.

The confinement radiation monitors project employs U.S. equipment. Technology transfer in this project is largely limited to training in the use of the equipment.

#### **A.2.3 Safety Parameter Display Systems**

Safety parameter display systems are being provided to RBMKs, VVER 440, and VVER 1000 NPPs. These projects are very closely tied to another major commitment of the program in which the U.S. is

supporting the development of symptom based Emergency Operating Instructions. The SPDS and EOI provide the operator with the information needed to determine the state of the plant in an emergency and the instructions to place the plant in a safe stable state. In each of the SPDS projects, there is significant host country participation in the design of displays and the software that converts detector signal output into critical safety parameters. SPDS work stations are also being provided to interface with simulators. These developmental units are used in the development of software and displays. The host countries are being provided with the equipment and training required to expand and upgrade the systems in the future.

#### **A.2.4 DC Power Supply**

Safety grade DC power supply systems have been provided to Kola Unit 1, Kola Unit 2, and to Kursk NPP. At Kursk, non-safety grade batteries were also provided to enable non-safety electric loads to be separated from safety electric loads. The systems consist of battery cells, seismic resistant stands, and DC switch boards. In the base programs, technology transfer has been provided in the sizing of batteries and switch boards but not in the supply of equipment. Although there are a number of plants in the host countries that need to replace batteries, the long term demand for nuclear grade batteries is limited. In a review of technology transfer opportunities, discussions have been held with the Russian battery manufacturer Electroyaga. In a new task, Burns and Roe will be working with U.S. battery manufacturers and Electroyaga to identify areas in which technology transfer can be effective in developing and sustaining a host country capability. In addition, the experience gained in the Kola and Kursk projects is being transferred to the host NPPs through workshops.

#### **A.2.5 Emergency Water Supply**

Emergency water supply systems are being provided to both a VVER plant at Novovoronezh and an RBMK plant at Kursk. Emergency water supply of the type being supplied to these plants is not a standard system in U.S. plants but is being provided because of the lack of redundant water supply in the older Soviet-designed plants. The concept is very simple, a versatile water pump and a diesel generator mounted on a movable skid. This system is not defined as safety class because its use is not anticipated in the normal, design-basis response of the plant to an accident. The approaches taken in the two projects are dramatically different. In the RBMK project, which is being led by Burns and Roe, the U.S. developed the design (the performance criteria were developed by the plant) and manufactured the system from U.S. components. The process proceeded very quickly and the system is currently at the plant. In contrast, the VVER system is primarily being designed by Gidropress and Atomenergoproect, under an agreement between Parsons Power and MOCT. Unfortunately, this project is proceeding very slowly at substantially higher cost than the RBMK project. Technology transfer sometimes will require higher up front costs to achieve.

In either case, the design specifications will be made available to the host countries, in the event duplicate copies are desired.

### **A.2.6 Instrumentation and Control**

At this time, there are only two projects of this type and both are in the startup phase. Technology transfer is a key element of both projects. In the Ignalina component replacement project, Scientech will manufacture a number of replacement modules using the same form, fit and function as the initial design but with modern technology. There is an extensive testing program associated with the project in both the U.S. and Lithuania. Scientech will manufacture 100 modules and then transfer the technology to a Lithuanian company to manufacture an additional 200 units. Quality assurance training is being provided to the Lithuanian company in March 1997.

A similar project is being initiated in Russia with the support of Rosenergoatom. In this project, the first step will be to identify a module that is a particularly difficult replacement problem for the plants and for which the long term market is high. Rosenergoatom is also in the process of identifying the most qualified component manufacturing companies in Russia to whom the capability will be transferred.

### **A.2.7 Primary System Integrity**

In two closely related tasks, BNL has provided hand held ultrasonic equipment to Kursk NPP and Burns and Roe is providing automated equipment. Because this type of equipment requires considerable skill to use, the training being provided to the plant staff is fairly extensive. Plant staff are receiving a one-month training course in the U.S. This activity area is being transitioned to the maintenance area. Further technology transfer opportunities will be the responsibility of that organization.

### **A.2.8 Plant Decommissioning**

This task is fundamentally an *Information Exchange* task. BNL and Kurchatov Institute, under the management of PNNL, are collecting the world-wide experience base on actual decommissioning activities that have occurred. This is being used to develop prototype decommissioning documentation for the Leningrad Unit 2 NPP.

### **A.2.9 Circuit Breaker Technology**

A new start that is planned for FY 97 is a project to assist the NPPs in solving problems with circuit breakers. In a survey of plant needs performed by Rosenergoatom, circuit breakers consistently were identified as a serious common problem. PNNL and Rosenergoatom are in the process of developing a work plan in which the focus would be to develop an in-country capability to produce circuit breakers for the NPPs.

### A.3 Plant Safety Evaluation

Technology transfer in this area is in many respects a natural result of the undertaking and completion of safety analysis projects. Although the technology transfer that has occurred to date has been largely successful, it has been focused at small groups of people, from specific institutes, attending training sessions or workshops and working on projects of limited scope. In contrast, the plant specific, in-depth safety analysis *Joint Projects* that are now just starting have the promise of significantly increasing the possibility to build a sustainable safety infrastructure that can continue to support plant safety evaluation needs in the future. Details of how Plant Safety Evaluation is addressing specific technology transfer mechanisms is given below.

An *Information Exchange* will be sponsored in September 1996 in Obninsk, Russia on Analytical and Computational Tools for the Safety Assessment of SDRs. In October 1996 a probabilistic risk assessment (PRA) workshop will be cosponsored with the IAEA at the Czech Republic's Nuclear Research Institute (REZ). The objective is to resolve discrepancies in modeling assumptions and databases among the different PRA studies of VVER-440 reactors. Safety analysis specialists from Russian, Ukrainian, and Central and Eastern European power plants, and technical organizations will address modeling assumptions, initiating events, and component reliability data, with the goal of agreeing on consistent assumptions. Participation of a limited number of Western European and U.S. experts is also expected. These types of wide audience exchanges/workshops will continue to be sponsored and promoted. In addition, small workshops and training courses focused in areas such as thermal hydraulic analysis and introduction to probabilistic analysis techniques are delivered to host country safety analysis specialists who are participating in *Joint Projects*. These focused exchanges provide the host country participants introduction and exposure to safety analysis methods and techniques that are necessary for performing internationally accepted analyses.

A number of in-depth safety assessment *Joint Projects* are being carried out at selected NPPs in Russia (Kola, Leningrad, and Novovoronezh NPPs) and Ukraine (South Ukraine and Zaporizhzhya NPPs). The objective of these projects is to provide a documented safety design basis and a documented plant risk profile to support safe plant operation and to provide justification for proceeding with appropriate safety upgrades. These in-depth analysis projects are organized with the plant in a leadership role, subcontracting of various technical activities by the plant to host country technical organizations, and a western expert(s) providing on-site technical mentoring and management assistance. In these projects it is stressed that the work is directed and carried out by the plant staff together with their supporting subcontracted technical organizations. The western expert role is restricted to one of technical mentoring and management assistance. This approach ensures that the plant maintains ownership of the product while at the same time developing the indigenous capability of the host country technical organizations to continue to provide technical support to in-country NPPs. Plant ownership of the product is absolutely necessary to guarantee the long term application of high quality safety analysis to decisions regarding the operation of the plant. At the same time the development of safety analysis capability at the technical organizations will build infrastructure that can continue to support the safety analysis needs of the plants we have selected as well as other in-country plants.

A limited number of *Personnel Exchanges* will be supported. In these cases, safety analysis specialists from the host countries will take temporary assignments at the U.S. National Laboratories to participate in a number of safety analysis activities. An assignment of one safety analyst from the Kola NPP to build RELAP graphical interfaces, known as a NPA mask, is expected to take place in FY 97.

An extensive amount of *Capability Transfer* has occurred in the Plant Safety Evaluation area. This encompasses a number of activities including:

- i) The transfer of U.S. developed safety analysis codes such as the thermal hydraulics code RELAP (through CAMP membership), the beyond design basis accident code MELCOR, and the PRA code IRRAS;
- ii) The acquisition of computer hardware to run the software;
- iii) Training in the use of these codes and;
- iv) Training in the implementation of various safety analysis techniques and methodologies.

#### **A.4 Fuel Cycle Safety**

Through *Capability Transfer* Ukraine has been provided with an approach for the safe, secure storage of spent fuel in dry containers. In future work, U.S. experience in the regulation of research reactors and fuel cycle facilities will be transferred to regulators.

#### **A.5 Legislative and Regulatory**

The objectives of the Legislative and Regulatory program element are focused completely on technology transfer. The intent is to transfer U.S. experience in nuclear legislation and regulation to the host countries. This is primarily accomplished in the form of *Information Exchange* by performing workshops for host country personnel in the areas of: safety analysis, event reporting and analysis, transportation, and training techniques. It is expected that these activities will result in a stronger, more independent nuclear safety regulator.

Computer codes have been transferred to the regulators in the host countries for performing safety analyses. In this manner, the regulators have obtained the capability to independently verify the calculations of the design organizations and make more informed regulatory decisions.

The U.S. will not participate in *Joint Projects* in the regulatory area with the host countries because of liability considerations. Furthermore, reactor regulation is considered a national prerogative. However, it is planned to have some GAN inspectors assigned to a DOE facility on a temporary basis. By means of *Personnel Exchange*, GAN personnel will be trained in DOE inspection and oversight techniques.

# Safety System Augmentation at Russian Nuclear Power Plants

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## *Abstract*

This paper describes the design and procurement of a Class 1E DC power supply system to upgrade plant safety at the Kola Nuclear Power Plant (NPP). Kola NPP is located above the Arctic circle at Polyarnie Zorie, Murmansk, Russia. Kola NPP consists of four units. Units 1 and 2 have VVER-440/230 type reactors: Units 3 and 4 have VVER-440/213 type reactors. The VVER-440 reactor design is similar to the pressurized water reactor design used in the U.S. This project provided redundant, Class 1E DC station batteries and DC switchboards for Kola NPP, Units 1 and 2.

The new DC power supply system was designed and procured in compliance with current nuclear design practices and requirements. Technical issues that needed to be addressed included reconciling the requirements in both U.S. and Russian codes and satisfying the requirements of the Russian nuclear regulatory authority. Close interface with ATOMENERGOPROEKT (AEP), the Russian design organization, KOLA NPP plant personnel, and GOSATOMNADZOR (GAN), the Russian version of U.S. Nuclear Regulatory Commission, was necessary to develop a design that would assure compliance with current Russian design requirements. Hence, this project was expected to serve as an example for plant upgrades at other similar VVER-440 nuclear plants.

In addition to technical issues, the project needed to address language barriers and the logistics of shipping equipment to a remote section of the Former Soviet Union (FSU).

This project was executed by Burns and Roe under the sponsorship of the U.S. Department of Energy (US-DOE) as part of the International Safety Program (INSP). The INSP is a comprehensive effort, in cooperation with partners in other countries, to improve nuclear safety worldwide.

A major element within the INSP is the improvement of the safety of Soviet-designed nuclear reactors.

## I. INTRODUCTION

After the Chernobyl accident in 1986 and the breakup of the Soviet Union, the U.S. made commitments at the 1992 G-7 Conference to provide assistance in reducing the risks associated with the continued operation of the older Soviet-designed reactor types i.e., RBMKs and VVER-440/230s.

These commitments resulted in cooperative engineering efforts between the U.S. and host countries of the Former Soviet Union (FSU). The US-DOE, under the INSP, manages projects that strengthen the nuclear safety culture and infrastructure of nuclear power plants within the FSU. In early 1994, Burns and Roe became a major contributor to safety upgrade projects sponsored by the US-DOE.

Kola NPP Units 1 and 2 were built during the period from 1965-1974. During this time frame, international regulations governing nuclear power plant emergency DC power supply systems had not yet been developed. Consequently, the design of the existing Unit 1 and Unit 2 emergency DC power supply system reflected the prevalent engineering and design practices employed at Russian fossil fueled generating stations.

VVER-440/230 Nuclear Power Plants typically have 230-V DC emergency power supply systems that do not satisfy present day requirements for design basis accident mitigation. The VVER-440/230 DC power supply configuration could present a potential hazard during the remaining design life of these plants. Availability of a reliable, seismically qualified Class 1E DC power supply source is an essential requirement of safe-shutdown capability at nuclear power plants. Therefore the US-DOE agreed to provide

nuclear qualified Class 1E batteries and the associated DC distribution boards to Kola NPP Units 1 and 2. This equipment would satisfy design requirements stipulated by the Russian participants as well as comply with the Class 1E qualification requirements typically imposed for a nuclear power plant in the United States.

## II. RUSSIAN SIDE RESPONSIBILITIES

This project was a cooperative effort between the U.S. and Russia. AEP, the Russian design organization, was responsible for identifying the technical design requirements for Russian nuclear power plants. Kola NPP site personnel were responsible for the installation, operation, and maintenance of the new equipment. GAN was responsible for providing the applicable Russian codes and standards and confirming that the new equipment and design satisfied current Russian regulatory requirements.

The Russian participants identified, separated, and re-assigned safety related electrical loads to provide physical and electrical separation between redundant safety trains and from non safety related loads. They also modified the existing battery rooms and DC switchboard rooms to provide separate rooms for redundant trains of the DC power supply equipment. Updated electrical one line diagram information and seismic floor response spectra were provided by the Russian side for the preparation of the equipment specifications for the project. Updated DC load profiles were provided for sizing the new batteries. The transfer of technical drawings proved to be an effective means of communication, in view of language/terminology differences. The Russian side developed a plant modification package that provided the detailed design for rerouting existing cables, routing new cables, as well as instructions for the installation and testing of the new equipment.

## III. DC SYSTEM CONFIGURATION

### A. Existing DC System Configuration

The existing 230V DC system at KOLA NPP consisted of the following major components:

- 1 battery and 1 DC Switchboard for the Unit 1 safety-related DC Loads
- 1 battery and 1 DC Switchboard for the Unit 2 safety-related DC Loads

- 1 battery and 1 DC switchboard for the Unit 1 & Unit 2. non safety-related DC loads as well as non safety-related loads common to both units

A 150KW, Invertible Motor Generators (IMG) was connected to each safety related DC Switchboard and the common non safety-related DC Switchboard. The DC system also included an additional IMG, which served as a backup.

An IMG is a coupled DC machine and AC synchronous machine set. Each IMG has its own voltage regulator and can be used as either a motor or a generator. Russian design practice is to normally configure the IMG so that it receives AC input power on the synchronous motor portion of the IMG. The AC motor then drives the DC machine portion to provide a regulated DC power output, thereby using the IMG as a battery charger. During loss of AC power, the IMG works in the opposite direction. The unit battery provides DC power to the IMG and the IMG is used as an inverter to provide AC power for safety-related AC power loads. This practice reflects the design philosophy at the time the plant was constructed. Current Russian design practice uses static chargers to provide a battery charging function and solid state inverters to supply critical AC loads.

Although the original plant design provided redundant safety related equipment, it did not provide redundant electrical distribution systems nor satisfy current single-failure criteria. A single 230-V DC power source was provided for the safety related loads at each unit. DC switchboards were rated to support their connected loads. The DC battery discharge capacity was based on the original one-half hour accident mitigation profile. These equipment could not support the addition of redundant electrical loads to the plant DC distribution system. Seismic and environmental qualification for essential components did not exist.

### B. New DC System Configuration

The modification at Kola NPP provided five safety-related Class 1E batteries and DC switchboards. The new configuration consisted of:

- two redundant Class 1E batteries and associated DC switchboards for Unit 1 safety related loads
- two redundant Class 1E batteries and associated DC switchboards for Unit 2 safety related loads

- one battery and DC switchboard for the non safety-related DC loads for Unit 1 and Unit 2, as well as non safety-related loads common to both units.

Although normally aligned to non safety-related loads, the non-safety-related DC distribution system could be reconfigured to use the non safety-related battery as a backup safety-grade DC power supply. Consequently, all equipment was designed procured, tested, and installed to comply with safety grade standards.

Batteries and DC switchboards were procured and tested in accordance with current IEEE standards applicable to nuclear qualified DC power supply equipment. The batteries and DC switchboards were seismically and environmentally qualified in compliance with Regulatory Guide 1.89, 1.100 and IEEE 323, 344, and 535. The batteries were sized in accordance with IEEE 485 to assure that the batteries had sufficient capacity to power redundant safety loads during post accident conditions. The battery manufacturer provided maintenance and post installation testing recommendations which complied with IEEE 450.

#### IV. BATTERIES AND RACKS

##### A. Existing Battery and Rack Design

The battery cells were lead acid type with lead calcium grid plates. However, the battery cells were of an obsolete cell design consisting of a transparent glass jar and an open top design that is potentially prone to degradation or failure under a Safe Shutdown Earthquake (SSE). In this design, the plates and other cell components were exposed to the environment.

This open top cell design required a large ventilation system to remove the large amount of potentially explosive hydrogen gas that could be generated during battery charging.

The batteries were installed on ceramic insulators on a concrete platform in a single tier configuration. This battery mounting arrangement did not include any restraining rails. Battery inter-tier connections utilized bare solid copper wires. These battery inter tier connections were suspended from the ceiling. The battery cells were susceptible to be dislodged during a seismic event, breaking inter cell connections, spilling electrolyte, and rendering the battery inoperable.

Further, the batteries were reaching the end of their expected operational life.

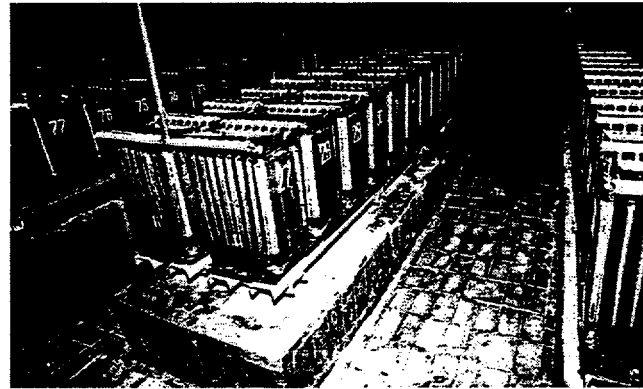


Figure 1. Existing Batteries at Kola NPP

##### B. New Battery And Rack Design Criteria

The new batteries and racks [1] were based on current U.S. nuclear industry standards. Normal and post accident environmental conditions and SSE floor response spectra were obtained for Kola NPP. The batteries were environmentally qualified to the normal and post accident environments at Kola NPP. The battery cells were seismically qualified to assure that the battery would be able to deliver full capacity during and after an SSE. The batteries were sized and tested in accordance with applicable IEEE standards to assure that the delivered battery would have sufficient capacity to support the emergency duty load profile provided by the Russian side. Battery sizing included temperature compensation for battery room ambient and an aging factor to ensure 100% capacity at the end of the battery's 20- year qualified life.

The battery racks were seismically qualified to assure they would remain functional during and after an SSE. The battery rack design was a two tier rack design which provided a small "footprint" and allowed installation in limited available space.

##### C. Special Battery Design Considerations

The updated VVER accident mitigation load profile had a 2 hours duration with a very high load demand during the first minute. To accommodate this condition, battery sizing per the procedure of IEEE 485 resulted in a substantial battery nominal capacity (2440 Amp-Hour). This size approached the limit of readily available qualified Class 1E batteries manufactured in the U.S. The undesirable consequence of a very high capacity is a correspondingly high available short circuit battery contribution to the DC power supply system. The chosen battery had an  $I_{sc}$  of ~21KA. The IMG has an  $I_{sc}$  of ~6KA. This issue had

to be carefully engineered so that the equipment interrupting rating of the new DC switchboards (30KA) and existing downstream equipment was not exceeded.

Special consideration was given to the method of shipping the batteries overseas into the Arctic circle. The scheduled plant outage required a winter shipment potentially exposing the battery cells to extreme sub freezing temperatures. Previous Russian practice was to ship batteries "dry", i.e., without the cells filled with electrolyte. The U.S. battery manufacturer's practice for safety grade batteries required that the batteries be shipped "wet", i.e., with cells filled with electrolyte. After the battery cell plates are formed and filled with electrolyte, they undergo IEEE 450 discharge testing. This provides positive indication that the delivered battery can supply rated power and perform its safety function. If the electrolyte were to then be removed, special precautions would be necessary to prevent exposing the plates. Further, existing battery environmental qualification could not easily be applied to "dry" cells. "Dry" shipment would still require shipment and handling of the electrolyte. Consequently, the batteries were shipped "wet." This required special shipping arrangements that are addressed later.

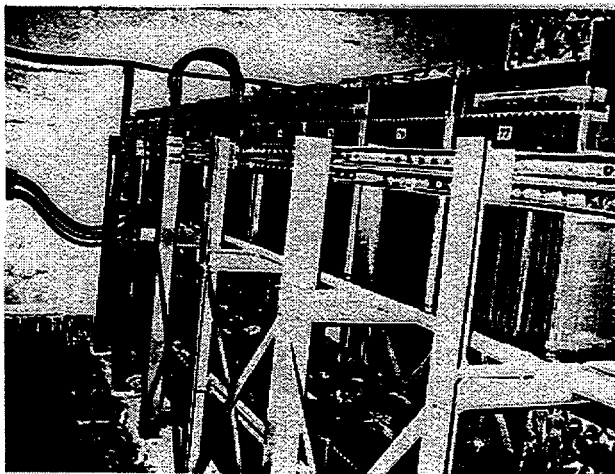


Figure 2. New Batteries at Kola NPP

## V. DC SWITCHBOARDS

### A. Existing DC Switchboards Design

Each switchboard included exposed uninsulated copper main buses. The main buses are separated in two sections by a disconnect switch. Each load is

connected to these two bus sections via separate load cables but powered from only one of the bus sections. This scheme allows a power source transfer and isolation of one set of load cables when locating a feeder ground.

The main buses and load switching devices are located in an open back metal switchboard structure. The open back construction is outdated and is not compatible with the water sprinkler fire suppression system. The switchboards are equipped with minimal graphic displays.

Engineering evaluation of the construction features indicated that:

- a) probability of fault occurrence on the uninsulated main buses located in open back enclosure is high,
- b) the enclosure design as well as internal component are not likely to survive a seismic event,
- c) the existing distribution scheme would not support single-failure criteria,
- d) the switchboard design would not comply with either the current US Class 1E equipment qualification requirements or current Russian standards.

### B. New DC Switchboard Design Criteria

The new DC switchboards [2] have been designed and constructed in compliance with the U.S. nuclear industry standards for Class 1E equipment. The design has also been verified to comply with the current Russian design requirements. The switchboard enclosures have been structurally designed to meet seismic qualification. The switchboards have been provided as NEMA 12 enclosures, thus protecting the equipment from sprinkler system actuation. Each distribution system component has been commercial grade dedicated to comply with the Class 1E qualification requirements.

Ratings of the load feeder breakers and fusible switch units have been carefully selected to reliably protect feeder cables and loads and to coordinate with downstream protection devices. The switchboard buses have been designed to accommodate the Russian approach for ground fault detection. Display meters for voltage, load current, battery discharge current, battery float current, and charging current have been provided. A graphic display of mimic buses have been included on the switchboard front panel to aid operation of the boards.

### *C. New DC Switchboard Design Considerations*

The design of the new DC switchboards accommodated the following unique Russian design requirements:

- a) two bus sections within the switchboards to allow load switchover to accommodate feeder ground search capacity,
- b) use of existing invertible motor generator sets in lieu of the standard U.S. practice of using static battery chargers.

After evaluation of the standard Russian design practice for ground search, a U.S. device for locating DC system grounds, the DC Scout [3], was proposed to the Russian side. Because of a lack of familiarity with this device and because of the prevalent Russian design practice, this approach was not accepted initially for Kola NPP. However, DC Scouts were provided to the Russians for future evaluation. Based on subsequent successful trials of the device, GAN and AEP were able to accept the device, thereby eliminating the second bus section and duplicate motor feeders for future safety augmentation projects such as KURSK NPP.

Use of the invertible motor generator sets resulted in higher available short circuit currents. Circuit interrupting devices with a 30,000A DC short circuit rating were selected to address this special need.

## VI. NONTECHNICAL ISSUES

### *A. Translation*

Nontechnical issues also became part of the DC system upgrade. It was very important that technical standards and design requirements were properly translated. Technically knowledgeable interpreters were necessary to provide accurate translation of engineering terminology. Phone calls and faxes were translated on both sides of the ocean. Russian and U.S. design offices were separated by eight time zones making routine communication a logistical exercise. Routine manufacturing exercises, such as designating equipment nameplates, wire markers, etc., had to be translated properly. This included the use of the appropriate Russian terminology.

### *B. Shipping*

Shipping equipment to the Arctic circle was also a concern. Exposure to severe sub-freezing temperatures can damage a battery. Temperature-controlled shipping containers were used to protect battery electrolyte during sub-freezing temperatures. Temperature and vibration monitors were included in the battery shipment to monitor safe passage during overseas shipping and document that the equipment was not exposed to any conditions that might jeopardize equipment qualification or void equipment warranties.

### *C. Customs*

In order to arrive at its destination, the equipment must be processed through Customs. It was critical that a copy of the proper documentation (in Russian and English) was provided to the proper authorities prior to shipment to expedite the process. The official documentation accompanied the equipment.

### *D. Communication And Correspondence With Russia*

Proper communication and correspondence was critical to the success of the project. Initial site visits gathered site specific information. Field walk-downs confirmed available space. The project had to coordinate equipment procurement and delivery to support unit outage schedules. Key Russian participants visited U.S. equipment manufacturers to acquaint the Russian side with the U.S. design and manufacturing practices and to assure conformance with Russian design requirements. GAN/AEP review and concurrence of the design was documented in meeting protocols that included an itemized listing of Russian design requirements and the corresponding U.S. design requirements indicating compliance.

## VII. DOE INVOLVEMENT AND GOALS

The initial goal of the US-DOE was to provide equipment and technical assistance to support cooperative nuclear safety projects in the Former Soviet Union. KOLA NPP was chosen as a pilot program. The final goal is to provide a means for the FSU to develop internal manufacturing and design capabilities via a transfer of technology. This process will afford opportunities for U.S. manufacturers to establish technical collaborations and manufacturing arrangements with FSU firms.

## VIII. TECHNOLOGY TRANSFER

Within the Kola Reliable DC Power Supply Project, initial discussions were held with Electrotyaga, a Russian battery manufacturer to determine the viability and extent of technology transfer. Preliminary observations indicate that the range of battery technology transfer opportunities could be:

- Full manufacturing capability within Russia
- Partial manufacturing within Russia, with some procurement outside Russia
- Procurement of sub-components with assembly inside Russia.

As part of the continuing effort for battery technology transfer, additional discussions will be held with U.S. and Russian manufacturers to explore technology transfer opportunities. The viability of each of the above strategies will be made including consideration of economics, potential market, interest among U.S. and Russian participants, types of technology to be transferred, and the capability of Russian partners to implement required technologies.

Future plans also include a visit by representatives of a Russian battery manufacturer to observe the U.S. battery manufacturing process first hand. The ultimate goal is to effect technology transfer to an extent that Russian manufactured batteries will be installed at future INSP sponsored battery upgrade projects within the FSU.

## IX. CONCLUSIONS

Since the inception of U.S. participation in the INSP, the DC power supply project at Kola NPP was one of the early executions of an equipment supply project in which U.S.-Russian technical cooperation was demonstrated successfully. The plant upgrade has been accepted by all appropriate Russian organizations. The equipment has been successfully installed in Unit 2 and is functioning properly. Installation of the Unit 1 and common DC power supplies are expected to be installed by December 1996. Strict adherence to technical, quality assurance, and regulatory requirements resulted in the successful design of this project. It is hoped that this project can be used as a model for future safety-augmentation projects in Russia and other FSU countries.

## IX. ACKNOWLEDGMENTS

The authors would like to acknowledge the international cooperative spirit that was instrumental to the successful completion of this project. We wish to thank the following individuals for their cooperation, dedication and hospitality.

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Alexander Semenov	Deputy Electrical Shop Supv., Kola NPP

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## X. REFERENCES

- [1] Batteries and Racks were supplied by Nuclear Logistics Inc., 7461 Airport Freeway, Fort Worth, Texas 76118.
- [2] D.C. Switchboards were supplied by United Controls International, Inc., 1554 Litton Drive, Stone Mountain, Georgia 30083.
- [3] D.C. Scout Ground Locator was supplied by H.J. Arnett Industries Inc., 7500 S.W. Tech Center Dr. #130, Portland, Oregon 97223.

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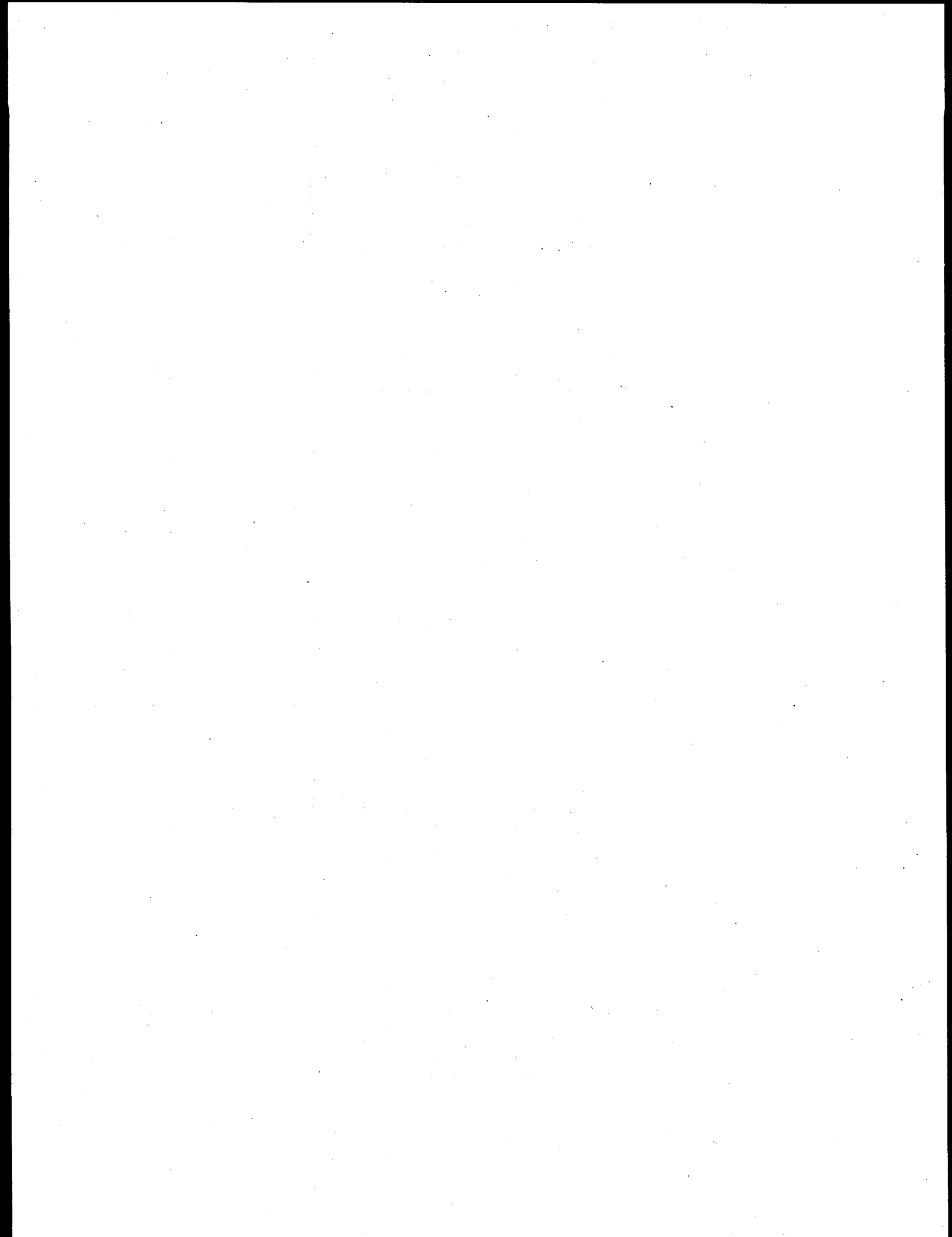
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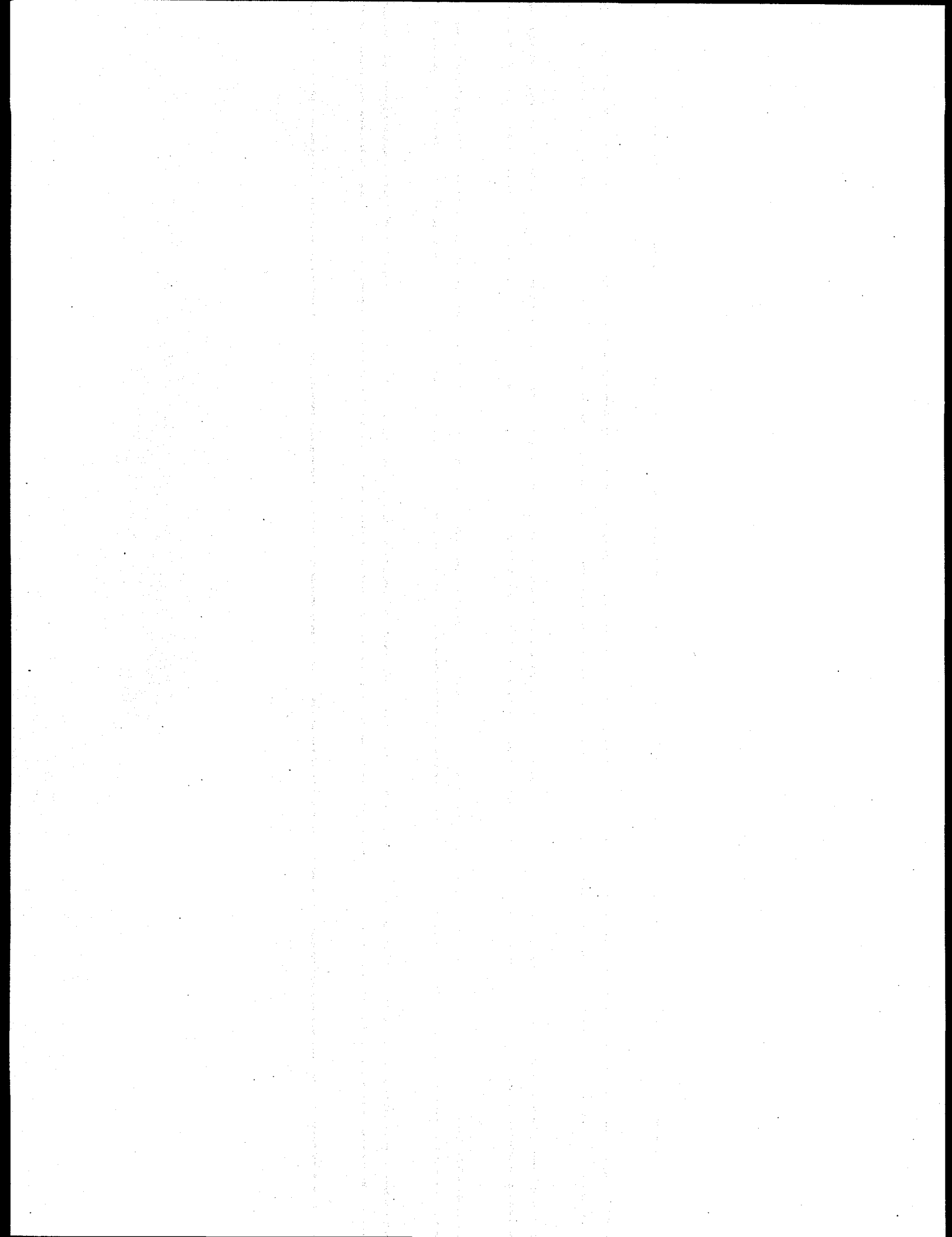
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## **Appendix E**

### **Strategy Document**





STRATEGY DOCUMENT

# Improving the Safety of Soviet-Designed Nuclear Power Plants

## Strategy Document

Office of Nuclear Energy, Science and Technology  
U.S. Department of Energy

February 1997



# **Improving the Safety of Soviet-Designed Nuclear Power Plants**

## **Strategy Document**

Office of Nuclear Energy, Science and Technology  
U.S. Department of Energy

February 1997







## Summary

The 1986 disaster at the Chernobyl nuclear power plant and subsequent investigations have revealed significant safety concerns and risks associated with continued operation of Soviet-designed reactors (SDRs). Today, there are 67 nuclear power reactors operating in the Central and Eastern European Countries, Armenia, Russia and Ukraine. Many of these reactors have deficiencies in safety equipment, training, safety procedures, and oversight. Some problems have been exacerbated by the breakup of the Soviet Union and the slow pace of economic restructuring and reform which leaves these plants without the resources needed to fully fund their safety needs. Equipment shortages are commonplace, many nuclear professionals suffer from low or erratic pay, and comprehensive government infrastructures to regulate these plants are not yet in place. Such conditions, if not corrected, substantially increase the risk of a nuclear accident in Ukraine, Russia, Armenia, or in Central or Eastern Europe.

For the past eight years, the United States has participated in efforts to upgrade the safety of Soviet-designed reactors. These efforts have evolved from an initial, limited exchange of nuclear power plant operators to the present-day multifaceted, comprehensive program. The program has become more extensive and longer term because the problems at SDRs are now more fully understood. There are no "quick fixes" that would result in these plants achieving adequate levels of safety.

The purpose of this document is to define the mission and vision of the U.S. Department of Energy's program for improving the safety of Soviet-designed nuclear power plants and to describe the basic strategy for program implementation. A fundamental part of the strategy is definition of the program's completion, or "end points." In addition, this document presents summary-level budget projections for completion of the program. The overall strategy and rationale for the end points, supported by the budget projections, provide the basis for a sound, viable program implementing the administration's policy.

Based on the program strategy, it is believed that the program should continue through the year 2003, with a currently estimated budget at completion near \$543 million.





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## Background

### Statement of Problem

Operating Soviet-designed reactors pose significant radiological risks due to deficiencies in safety equipment, training, operating and emergency procedures and regulatory oversight. These deficiencies vary in type and degree among the different Soviet reactor designs and generations. Currently, there are 65 operating nuclear power reactors. These reactors are located in nine countries as presented below.

	Russia <sup>(a)</sup>	Ukraine	Bulgaria	Czech	Hungary	Lithuania	Slovakia	Armenia	Kazakhstan
RBMKs	11	1				2			
VVERs									
-440/230s	4		4				2	1	
-440/213s	2	2		4	4		2		
-1000s	7	11	2						
BN-600	1								
BN-350									1

(a) Other Russian reactors include 4 light-water-cooled, graphite-moderated reactors.  
 BN = Breeder reactor.  
 RBMK = Boiling-water, graphite-moderated, pressure-tube reactor.  
 VVER = Pressurized, light-water cooled and moderated reactor.

Based on evaluations of the Soviet-designed reactors, numerous deficiencies in safety have been identified. The principal deficiencies for the major reactor types are listed below.

#### RBMK

- no massive steel/concrete containment structure
- accident mitigation systems are limited and ineffective
- inadequate fire protection systems
- deficient separation and redundancy of electrical and safety systems
- inadequate operating and emergency procedures.

#### VVER-440/230

- reactor confinement inadequate to accommodate large pipe breaks
- reactor confinement has poor leak-tightness and poor hydrogen mitigation

- inadequate emergency core cooling systems
- inadequate fire protection systems
- inadequate operating and emergency procedures.

#### **VVER-440/213**

- inadequate separation of plant safety systems
- reactor confinement has poor leak-tightness and poor hydrogen mitigation
- inadequate fire protection systems
- inadequate operating and emergency procedures.

#### **VVER-1000**

- inadequate separation of electrical systems
- inadequate fire protection systems
- inadequate operating and emergency procedures.

Many countries with Soviet-designed reactors suffer from electricity shortages, particularly during the winter. Also, nuclear power plants provide a significant percentage of the electricity needs in this region, e.g., 87 percent of the electricity in Lithuania, over 30 percent of the electricity in Ukraine, Bulgaria, Armenia, Hungary, and Slovakia, and 12.5 percent of the electricity in Russia. These shortages, however, are caused more by economic than technical constraints, i.e., the inability to purchase imported fossil fuels at world market prices and/or the failure to effectively restructure the power sector so that it is capable of generating the revenues necessary to fund investments in safer power alternatives. For these reasons, it is difficult for countries with these reactors to shut them down.

These countries continue to operate high-risk reactors despite the possibility of a catastrophic accident which could have enormous political and economic consequences. Such an accident could:

- undermine the stability of the government, potentially weakening a new democratically-elected government
- place at risk Western investments in the former Soviet Union countries with potential repercussions on international economies
- require billions of dollars in U.S. and international assistance to support recovery efforts
- reduce the continued viability of the nuclear power option throughout the world.

In consideration of the safety deficiencies and the continued reliance on these reactors, the United States and other donor countries have been providing assistance to reduce the risk at the least safe reactors, to enhance overall operational safety and training and to promote a strong independent regulator. Adopted at the 1992 Munich G-7 Summit, this multilateral safety assistance program has been carefully crafted to ensure assistance addresses the greatest safety risks at RBMK and VVER 440/230 reactors without, however, extending their operating lifetimes.

### **Underlying Reasons for Safety Deficiencies**

Soviet reactors were built with a different design philosophy which emphasized production over safety and assumed that timely human intervention would prevent serious accidents. Western design philosophy stressed safety over production and sought to develop highly automated safety and shutdown systems with minimal reliance upon ad hoc operator interventions. As a matter of policy prior to 1986, severe accidents were assumed impossible in Soviet-designed reactors and Soviet designers showed little interest in developments in Western safety design and technology. Because of these operational and design priorities, and the technical isolation imposed by the cold war, the designers, constructors, operators and regulators of Soviet nuclear power plants did not follow international safety practices.

The slow pace of political and economic reform following the breakup of the Soviet Union has continued to degrade nuclear safety conditions in several of these countries.

- Working relationships between employees at plants outside Russia and the design organizations in Russia have deteriorated considerably.
- Replacement parts are often not available, resulting in makeshift arrangements, including cannibalization of parts from partially-completed plants.
- Payments to nuclear power plants for electricity production are sometimes delayed and often not sufficient to pay total generation costs, let alone the costs for making safety improvements.
- Salaries for nuclear power plant operators are often not competitive with other job opportunities; regulators in most of these countries earn even less. Recently, because of severe funding shortages, salary/pay to operators at some nuclear power plants in Russia and Ukraine have been delayed for several months.

## **Program Approach and History**

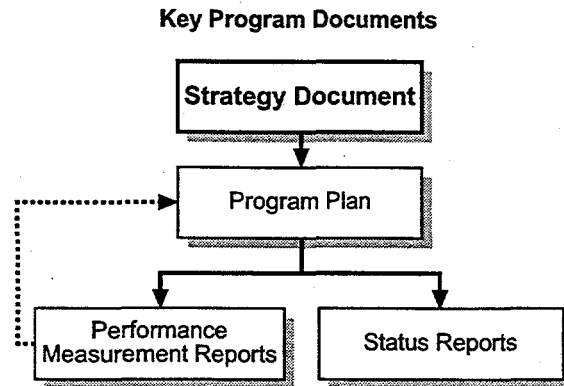
In consideration of the declining safety conditions, the program approach has been to: 1) implement short-term risk reduction through equipment upgrades at the highest-risk reactors; 2) improve operational practices and training at all nuclear power plants; and 3) provide the necessary technology, training and infrastructure support so that these safety improvements can become self-sustaining, enabling these countries to move forward on a success path to achieving a level of safety comparable to internationally accepted practices. This approach is addressed further in the strategy section and under each discussion of the six program goals in this document. The program is comprehensive, and is conducted in a manner consistent with guidance and policies established by the U.S. Department of State and the U.S. Agency for International Development. The program is also performed in collaboration with the U.S. Nuclear Regulatory Commission. The United States coordinates its safety assistance program with those of the International Atomic Energy Agency (IAEA), the Nuclear Safety Account at the European Bank for Reconstruction and Development, and those of other donors through the G-7 Nuclear Safety Working Group and the G-24 Nuclear Safety Assistance Coordination mechanism.

The program is an expansion of past efforts. Involvement of the United States in the Soviet civilian nuclear power program began with the Chairman of the U.S. Nuclear Regulatory Commission and the Chairman of the USSR State Committee for the Utilization of Atomic Energy signing a Memorandum of Cooperation in the Field of Civilian Nuclear Reactor Safety in April 1988. In 1990, the U.S. Department of Energy (DOE), through the Joint Coordinating Committee on Civilian Nuclear Reactor Safety, initiated a modest program to improve operational safety at the Novovoronezh nuclear power plant. Subsequently, in May 1992, Secretary of State Baker announced that the United States would work to enhance the operational safety of Soviet-designed reactors, to provide for risk reduction measures for the least safe plant designs, and to enhance the capability of the regulatory organizations. These three goals, as well as a commitment to support efforts to minimize the remaining time of operation for the least safe reactor types (RBMK and VVER 440/230), were later endorsed by the G-7 at the Munich Summit and constitute the common approach to improving the safety of Soviet-designed reactors.

## **Purpose of Document**

This document defines the program's mission and vision and describes the basic strategy for program implementation. Detailed plans for program implementation, including more detailed budget information, are contained in the report, *Improving the Safety of Soviet-Designed Nuclear Power Plants, Program Plan*. Status and progress in each

technical area are periodically documented in two reports: *Improving the Safety of Soviet-Designed Nuclear Power Plants, Status Report* and *Improving the Safety of Soviet-Designed Nuclear Power Plants, Performance Measurement Report*. The relationship between these reports is illustrated below. All reports are issued by the Office of Nuclear Energy, Science and Technology, U.S. Department of Energy. They are accessible on the Internet at <http://insp.pnl.gov:2080>.



## Mission

Consistent with the policy of the G-7, the mission of the program is to reduce the risks at Soviet-designed nuclear power plants (without encouraging long-term operation of RBMKs and VVER 440/230s) and assist these countries to implement a self-sustaining nuclear safety improvement program capable of reaching internationally accepted safety practices.

## Vision

In defining and implementing this program, the vision is that within a decade:

- Soviet-designed nuclear power programs will be brought up to internationally accepted practices in both their operation and regulation
- the importance of nuclear safety over all other priorities will be reflected in the regulation, operation, and professional attitudes of the designers, operators, and regulators of nuclear facilities
- host countries will have the infrastructure, expertise, and resources to participate actively and responsibly within the international nuclear power community.

## Strategy

International assistance efforts alone cannot resolve the safety deficiencies inherent in these nuclear programs. The goal of external assistance efforts is to help host countries develop their own capability to more safely operate and regulate nuclear power plants. As their economies improve, they will be able to sustain and extend such improvements by their own efforts until they can reach internationally accepted standards in the operation and regulation of their nuclear programs. Therefore, the program strategy is to work with host country nuclear power plant operators, regulators and support organizations to provide them the knowledge, technology, equipment and capability needed to achieve a self-sustaining nuclear safety improvement program. The relationships established during this program will enable the United States to monitor these nuclear programs and to respond to future safety problems. If progress appears unacceptable, the United States may need to consider further actions to assist the host countries in attaining internationally recognized practices.

The program is divided into five key technical areas. Improvements are required in each of these areas to improve safety practices in these countries. The five technical areas are:

- operational safety
- training
- maintenance
- safety systems
- safety evaluations.

To achieve and sustain internationally accepted safety levels, host countries must have in place domestic legislation consistent with their obligations under the International Nuclear Safety Convention, in particular laws providing for a strong, independent regulator and legislation providing adequate nuclear liability protection to equipment suppliers. In addition, the power sector should be restructured on a sound, market basis to ensure that nuclear utilities are capable of securing adequate revenues to support safety.

The key technical areas were selected based upon evaluation of Soviet-designed nuclear plant safety hazards identified by the IAEA. Although the program sponsors projects in all of the areas categorized as deficient by IAEA, not every specific IAEA safety issue is addressed within the program. Through coordination with other international bodies and the host countries, however, all the IAEA safety issues are under consideration for resolution.

The selection criteria for projects in these technical areas address: 1) priority of safety needs; 2) cost effectiveness; and 3) host country commitment to ensure sustainability after U.S. support ends. In addition, work is selected in coordination with host country and other internationally sponsored safety programs to ensure U.S. projects complement activities undertaken by others.

In the five key technical areas, the mission will largely be achieved by following a pilot plant approach. One or two "pilot" plants, or in some cases a group of selected plants, receive training, technology, and physical improvements. A sufficient number of pilot plant projects will be completed within each key area to serve as a safety improvement model for all host countries. As an integral part of each project, technology and training are provided to equip each host country to extend improvements independently. Using program support, host countries are expected to capitalize on the momentum established at the pilot plants to extend improvements to other facilities. In some areas, where the host country infrastructure is very limited and the economic conditions preclude independent actions on a timely basis, activities will be extended beyond pilot plants.

Regulatory organizations are provided the tools, training, and technology so that they can provide proper regulatory oversight for U.S. DOE sponsored nuclear safety projects. Similar capabilities are also provided to improve regulatory oversight for selected non-reactor nuclear facilities for which DOE has unique expertise and experience. Information related to international practices, nuclear liability legislation, and the importance of laws providing for a strong regulatory authority is provided to legislators and other decision makers in order assist them in understanding the importance of these issues and to facilitate informed decisions.

Establishment of a strong, indigenous nuclear safety culture is essential if the task of improving nuclear safety in these countries is to continue once the program is completed. An underlying purpose of the program, therefore, is to show host country nuclear plant and regulatory personnel examples of effective nuclear safety cultures so they will incorporate and sustain sound safety practices. Through workshops, seminars, and visits to U.S. nuclear plants, host country personnel learn that a strong nuclear safety culture not only protects plant workers and the public, but is also important to the efficient and financially viable operation of the plant.

## Goals

The program vision provides broad guidance for accomplishing the mission of reducing risks at Soviet-designed nuclear power plants and upgrading host country nuclear safety

infrastructure. Goals for each technical area have been established to elaborate the program vision and facilitate the development of specific projects.

The technical area goals are summarized below:

- **Operational Safety** - Implement the basic elements of operational safety consistent with internationally accepted practices.
- **Training** - Improve operator training to internationally accepted standards.
- **Maintenance** - Help establish technically effective maintenance programs which can ensure the reliability of safety-related equipment.
- **Safety Systems** - Implement safety system improvements consistent with remaining plant lifetimes.
- **Safety Evaluations** - Transfer the capability to conduct in-depth plant safety evaluations using internationally accepted methods.
- **Legal and Regulatory Capabilities** - Facilitate host country implementation of necessary laws and regulatory policies consistent with their international treaty obligations governing the safe use of nuclear power.

## End Points

To ensure that the program is aimed toward a defined and successful completion, end points for each technical area have been established. An end point defines the point at which host countries, their nuclear support organizations, and their nuclear power plants have achieved a functional level that places them on a self-sustainable path to meet internationally accepted nuclear safety practices. The end points are measurable, achievable targets which provide positive indication that goals have been met and the program has been successfully completed. The end points in each technical area are based primarily on the relative importance to safety, cost benefit, timeliness of results, and sustainability of projects by the host country.

The goals for each technical area, their accompanying end points, and the associated end point rationale and approach are described below.

**Goal 1. Host country nuclear power plants have implemented the basic elements of operational safety consistent with internationally accepted practices.**

**End Points:**

- The basic elements of operational safety are implemented at pilot plants by providing training, technology, methodology, and equipment. The basic elements of operational safety are:
  - Operational Control Procedures
  - Normal Operating Procedures
  - Abnormal Operating Procedures and Emergency Operating Instructions
  - Quality Assurance and Control Program including Corrective Action Tracking
  - Event Analysis and Reporting including Root Cause Analysis
  - Configuration Management Program
  - Self-Assessment Program
  - Plant Safety Review Board.
  
- Host country utility organizations and regulators are provided the capability to develop guidelines and criteria to enable them to transfer the basic operational safety practices to the other nuclear power plants in each host country.

**End Point Rationale:** Operating experience and evaluations by international nuclear organizations have determined that the conduct of operations, or the manner in which operators carry-out the daily functions of the plant, can often have as great an impact on nuclear safety as the design and condition of the physical plant. Nuclear experts generally agree on the basic elements of operational safety, which include procedures for both normal and emergency situations, a comprehensive quality assurance program, specific configuration control measures, and an extensive self-assessment and internal review process. Institution of operational safety elements can help improve the safety at Soviet-designed reactors independent of design or hardware deficiencies that may exist. The operational safety elements will foster a stronger safety culture and increase operator awareness of safety issues.

To reinforce the country-wide dissemination of operational safety practices, the program assists host country nuclear utility organizations and regulators in developing operational safety guidelines and criteria. These requirements will facilitate the transfer of methods and technology needed to ensure a basis for consistent, internationally accepted safety practices among Soviet-designed nuclear power plants.

**Approach:** The approach for improving the operational safety capabilities at Soviet-designed reactors is to perform operational safety projects at pilot plants, which generally include one or two plants of each design type in each of the host countries. In addition to working with the staff at the pilot plants, projects involve the host country utility and regulator. The objective is to develop the means (training, guidelines, criteria, requirements, etc.) for disseminating the knowledge and capabilities developed at the pilot plants to other nuclear power plants within the host country. Assistance and consultation also is provided to support the transfer of capability from the pilot plants to other plants. Different pilot plants are usually selected for each project in order to allow more plants to benefit from the program and assure that improvements are made at all types of Soviet-designed reactors. This approach also facilitates the transfer of technology between plants.

**Goal 2. Host country plants have implemented internationally accepted training programs for plant personnel in safe operating practices.**

**End Points:**

- Pilot plants have effective training programs and the equipment necessary to support these training programs (such as computers, software, view graph machines, mockups, and demonstration apparatus).
- Training specialists in each plant's training organization are trained in the Systematic Approach to Training. Host country regulators and utility organizations are trained to develop criteria for evaluating training programs and qualifying essential plant positions in order to affect transfer of training technology to all host country plants.
- Simulators exist at all nuclear power plant sites. Staff are knowledgeable in using the simulator for training and can operate, maintain, and upgrade simulator software and hardware.

**End Point Rationale:** Well-trained operators are essential to the safe operation of nuclear power plants. Such operators have a significant positive impact on the safety culture and on the ability to prevent or respond to abnormal events. Operator and plant staff training at Soviet-designed reactors have historically been weak with "on-the-job-training" forming the basis for operator qualification. Following the Three Mile Island accident, a formal, 'Systematic Approach to Training' (SAT) methodology evolved in the United States which has proven to be very effective. The Systematic Approach to Training identifies the knowledge and skills required for each staff position at a nuclear power plant, establishes a training program to provide and maintain the necessary knowledge and skills, and obtains feedback to ensure training remains current with plant

procedures and practices. Incorporation of the SAT method and provision of adequate training equipment greatly strengthens plant training departments, thereby improving operator training and overall plant safety.

Nuclear power utility organizations and regulators are instructed on the development of guidelines and criteria for contemporary, internationally accepted nuclear power plant training programs. The development of such requirements will facilitate the establishment of consistent country-wide training programs, reinforce the pilot plant training enhancements, and assure the dissemination of the training technology.

Additionally, full-scope simulators of reactor control rooms have proven to be one of the most effective tools available for training plant operators. Simulators provide operators the opportunity to practice responding to realistic emergency situations, thereby improving their capability to control and mitigate potential reactor accidents.

**Approach:** Training program enhancements are underway at two pilot plants, one in Russia (Balakovo) and one in Ukraine (Khmelnysky). Training staff are introduced to the Systematic Approach to Training methodology and are provided classroom training materials. They are assisted in developing selected classes, and then independently adapt the methodology in developing other classes tailored to meet the specific needs of their plant. After the training programs are developed at these two pilot plants, assistance is provided to transfer the training methodologies to other Soviet-designed nuclear power plants. In addition, technical assistance is provided to the host country regulators to help them establish criteria for training program content and personnel qualification. Simulators are planned for each site and will be provided by the program, by other international safety efforts, or by the host country itself.

**Goal 3. Host country nuclear power plants have implemented an effective maintenance program to ensure safety related equipment will function as intended.**

**End Points:**

- Pilot plants have the training, technology, and equipment to implement an effective maintenance program consisting of:
  - improved maintenance practices, procedures, and techniques
  - improved non-destructive examination practices and techniques
  - preventive maintenance based on component reliability data
  - systematic review of equipment failures including root cause analysis
  - spare parts and procurement systems in place consistent with Quality Assurance program requirements.

- Host country utility and regulatory organizations have developed guidelines and criteria to ensure the transfer of effective maintenance practices to the other nuclear power plants.

**End Point Rationale:** Inadequate maintenance is a major safety deficiency at most Soviet-designed plants. Based on recent information, 42% of the safety related equipment failures occurring at these plants were attributed to maintenance deficiencies. Improvement of maintenance practices and use of sophisticated, state-of-the-art maintenance equipment, therefore, has great potential for reducing failures of safety related equipment.

To facilitate the transfer of maintenance program enhancements to other nuclear power plants, host country nuclear power utility organizations and regulators will be trained to develop guidelines and criteria for modern, effective maintenance programs. This will promote consistent and effective maintenance activities at all nuclear power plants.

**Approach:** The focus of U.S. activities is to transfer proven international maintenance practices, training methods, and technology to pilot plants to assure that safety equipment will function reliably. Projects will include not only modern maintenance equipment, but also training on proper planning and performance of maintenance and analysis of equipment failures. Due to their extreme need, all RBMK sites were selected as pilot plants for maintenance program improvements. After the effectiveness of the RBMK maintenance upgrades is evaluated, assistance will be provided to transfer applicable maintenance technology to VVER 440 nuclear power plants.

The newer VVER 1000 plants have improved maintenance equipment and programs and do not require the same level of assistance. However, specific assistance to improve the ability to detect and identify defects in critical safety components is also being provided by improving non-destructive examination capabilities and inspection techniques.

**Goal 4. Host country nuclear power plants have implemented safety system improvements consistent with their remaining lifetime by alleviating major safety system deficiencies identified by independent reviewers.**

**End Points:**

- All plants, in cooperation with other international and host country programs, have corrected vital safety system deficiencies which can be corrected in a cost-effective manner by providing:
  - Reliable sources of DC power with separation of safety and non-safety loads and adequate capacity

- Backup sources of emergency feedwater
- Basic fire protection upgrades satisfying international practices for:
  - Fire detection and alarm instrumentation
  - Automatic and manual fire suppression equipment
  - Passive fire barriers
  - Personnel protection and fire fighting equipment.
- Pilot plants have corrected major safety system deficiencies by improving:
  - Timing, capacity and reliability of emergency AC power sources
  - Valve performance for safety system actuation, primary and secondary relief, and system isolation
  - Reliability of instrumentation and control systems, including display of safety information to operators.
- Pilot plants have performed a detailed safe shutdown study for fire hazards. Pilot plants have corrected principal safe shutdown vulnerabilities.
- Technology is transferred to host country plants and organizations to facilitate the incorporation of pilot plant upgrades at all plants and to sustain system upgrades, including assistance in reestablishing host country infrastructures for the supply or manufacture of nuclear safety system components.

**End Point Rationale:** The designs of Soviet nuclear power plants evolved and improved over time. Consequently, the deficiencies identified in independent reviews for the oldest plants (VVER 440/230s and RBMKs) are more severe than for the newer designs (VVER 440/213s and VVER 1000s). However, the remaining lifetime of the older designs is much less than for the newer plants.

The long-term international safety assistance goal is to encourage host countries to shut down VVER 440/230 and RBMK reactors. Therefore, one of the program objectives is to reduce the safety risks associated with continued short-term operation of these plants by providing equipment that alleviates major safety system deficiencies.

**Approach:** Projects will correct or assist in the correction of each of the major deficiencies identified in independent reviews of the plants. The total cost of resolving all safety system deficiencies far exceeds a reasonable funding level that could be provided

by the United States or other countries. Thus, two different strategies are undertaken to implement these corrections. The most critical upgrades are performed at all plants based upon host country priorities and in coordination with other assistance programs. For the less critical deficiencies, a pilot program is undertaken that demonstrates a means for resolving the deficiency. One or two pilot plants, which are selected based upon input from the host country and the evaluated need, receive the safety system upgrades. Technology transfer is then provided to facilitate the correction of the deficiency in all plants by the host country, including the reestablishment of a host country infrastructure for supply or manufacture of safety grade components.

Because the newer plants may operate for a longer period of time, the goal for the safety level of these plants is higher than the goal for the older plants. These plants should be upgraded over time to a level that approaches that of international practices. Most of the improvements at newer plants will be performed through commercial arrangements with host country vendors, thus helping develop an indigenous nuclear component manufacturing capability. In addition to resolving the deficiencies identified by independent safety reviews, upgrades should be undertaken to resolve deficiencies that are identified through the performance of safety and risk analyses and in the development of safety documentation for the plants. In general, program funded activities are limited to reestablishing the host country infrastructure to supply or manufacture safety components such that the host countries can undertake these safety upgrade activities on their own.

**Goal 5. Host country nuclear power plant operators and the technical support organizations have the capabilities to conduct in-depth plant safety evaluations using internationally accepted methods.**

**End Points:**

- Selected plants have completed in-depth safety evaluations in coordination with other international assistance programs.
- Design, regulatory, and operating support organizations have the sustainable infrastructure required to perform internationally accepted in-depth safety evaluations.

**End Point Rationale:** The performance of in-depth, plant specific safety evaluations is required in order to properly design and safely operate and regulate nuclear power plants. The existence of a comprehensive safety evaluation is also useful for prioritizing safety upgrades and for making decisions concerning whether to upgrade or replace existing plants.

Safety analyses for Soviet-designed reactors historically have been conducted by the design organizations with little or no input from the plant operator. One consequence is

that operators had limited involvement in establishing their own technical operating bases and insufficient knowledge concerning the design of their facility. Prior to the Chernobyl disaster, there existed a fundamental premise that serious accidents were impossible. Consequently, the safety evaluations that were performed for these reactors were not complete and the tools and data required for comprehensive analyses were never created. Comprehensive safety evaluations will verify the safety status of the plant design and also provide a tool to help plant operators and engineers make informed decisions concerning operations and design changes which affect safety.

**Approach:** The program has developed an approach to foster the establishment of a safety analysis infrastructure in the host countries by providing assistance to selected plants and their technical support organizations in completing in-depth safety assessments. In order to have the most positive impact on safety, the analyses will be completed with the leadership and active participation of the nuclear power plant staff.

Selection of the plants that will receive safety analysis assistance is based on the following rationale. The program will coordinate with other international assistance projects to ensure that analyses are not duplicated. All plants in Russia that are targeted for EBRD hardware upgrade grants and are required to complete an in-depth safety assessment will receive safety analysis assistance. In addition, assistance for the preparation of a formal Safety Analysis Report, as required by the EBRD grant agreements, will be provided. Additional plants in Russia will be chosen to ensure that an in-depth safety analysis is completed for at least one of each reactor design type and generation. Because Ukraine lacks safety analysis infrastructure, assistance will be provided to all plants in Ukraine needing safety analyses. This approach was chosen due to the presence of a large number of newer generation VVER-1000 units in Ukraine which will be operated for many years, and also because of the importance of safety analyses to overall plant safety.

No plants were selected for an in-depth safety analysis in the Central and Eastern European countries due to the relatively advanced state of the safety analyses already performed, the level of infrastructure that exists, and the degree of involvement by other international assistance programs. Some limited safety analysis support is provided in specific areas to accomplish the completion of technology transfer.

To help ensure that the newly developed safety analysis infrastructure remains intact and that the capability to perform safety analyses is transferred to nuclear power plants and technical support organizations, follow-on consultant support will be provided to the host countries. This support will include transferring and providing training on the use of state-of-the-art safety analysis tools and methodologies. The program will also support the development and validation of available safety analysis tools for application in the host countries as necessary to address regulatory requirements.

**Goal 6. Host countries have adopted necessary laws and regulatory policies governing the safe use of nuclear power.**

**End Points:**

- Host country regulators have the necessary tools and information (i.e., model regulations, sample codes and standards, training on international practices, computer hardware and software, etc.) to perform regulatory oversight of U.S. sponsored nuclear safety projects.
- Key policy personnel in all host countries have been advised of the benefits of subscribing to nuclear safety treaties and laws related to nuclear indemnification and nuclear safety convention practices and standards.
- Host countries have received comprehensive training on the safety and regulatory requirements to operate large research reactors and fuel cycle facilities.

**End Point Rationale:** Regulatory practices in the former Soviet Union countries have been weak historically, and many of the countries with Soviet-designed reactors have no nuclear legislative or regulatory infrastructure. Achieving and sustaining internationally accepted safety levels requires a strong, independent regulator, trained and equipped with modern regulatory tools. In addition, effective nuclear industry liability and indemnification laws are necessary to provide nuclear operators ready access to the services and equipment of commercial suppliers that meet international nuclear safety practices.

The involvement of the regulator in program sponsored safety projects is essential to help assure that projects will be approved by the regulator when completed. It is therefore important that the regulator has the training and tools required to assess the acceptability of cooperative safety projects. Helping to facilitate regulator involvement in program sponsored projects can also help convey to host country counterparts the importance which the United States places on the role of the regulator.

Laws that provide for a strong and independent regulator are a prerequisite for achieving sustainable safety levels consistent with international practices. Subscribing to international nuclear safety conventions also demonstrates the commitment of the host country to achieving internationally accepted safety levels. Subscription to international liability conventions combined with domestic liability legislation will provide host countries commercial access to U.S. and other international companies that can provide safety technologies that meet international nuclear safety practices.

Projects in this area are conducted in collaboration with the U.S. Nuclear Regulatory Commission who is responsible for improvement of the overall nuclear regulatory infrastructure in these countries.

**Approach:** Information related to international nuclear safety practices, nuclear liability legislation, and the importance of laws providing for a strong regulatory authority will be provided to host country legislators and other decision makers to assist them in understanding the importance of these issues and to facilitate knowledge-based decisions. Host country regulators will be trained through workshops and visits to the United States, and will be provided with representative, internationally accepted regulatory practices. These projects are closely coordinated with the U.S. Nuclear Regulatory Commission.

The DOE has expertise and experience in regulatory areas related to large research reactors and fuel cycle facilities. For the same reason that it is in our interest to improve safety in nuclear power plants, it also is important to share this expertise with host country regulators for these specialized nuclear facilities. Therefore, regulatory information, training, and tools for regulating specialized nuclear facilities are being transferred, as appropriate, to regulators in Russia and Ukraine.

## Selection of Projects

When the program began, an initial set of projects was selected based on requests for assistance from the operators of Soviet-designed reactors, and on input from international nuclear organizations who had evaluated these plants and identified safety deficiencies in numerous reviews that followed the Chernobyl accident. Project selections were also based on U.S. participation on international steering committees which were established to identify and prioritize key safety issues associated with Soviet-designed nuclear power plants. Further, the United States coordinated the selection of its projects with the members of the G-24 and international financial institutions who are also supporting safety upgrades at Soviet-designed nuclear power plants.

In addition to the above practices, projects are currently chosen by applying specific selection criteria in two phases. Proposed projects are first screened by program staff to ensure they will improve the nuclear safety of operating plants, prevent or contain core damage, and apply established technologies. Candidate projects which meet the screening criteria are evaluated in more detail by program staff and host country experts who apply the following evaluation criteria to determine if the project meets the program mission.

- **Impact on Safety**

The project is evaluated against available independent safety reviews and risk assessments to verify it improves safety. Regulatory involvement, technology transfer, sustainability, and the number of plants affected are also factored into the evaluation.

- **Cost Effectiveness**

Using a preliminary cost estimate, the project is reviewed in relation to other ongoing projects to determine the comparative investment in safety. Projects that complement and leverage benefits from other projects, use joint ventures with former Soviet Union countries, or enhance the host country's capability to undertake its own upgrades are given priority.

- **Host Country Commitment/Sustainability**

The host country's desire for the project and willingness to commit funds and personnel are reviewed to verify their ability to sustain the project for the long term. In the case of technical shortcomings, the project must transfer the technology and infrastructure needed for sustainability.

Based upon this evaluation and the availability of resources, priority and schedule are established for the project. This process ensures that projects are consistent with the policies and goals under which U.S. financial support is committed, the needs of the host countries are met, and the required resources are available.

## **Actual and Projected Budgets**

As mentioned in the Summary section, the program, as currently defined, is estimated to be complete in the year 2003, with a budget currently estimated at completion near \$543 million. Program funding through government fiscal year (FY) 1996 is \$195,450,000; FY 1997 includes \$82,630,000 (of which \$30,000,000 is pending). The currently estimated budgets for the out-years for program completion are:

- FY 1998 - \$50,000,000
- FY 1999 - \$54,354,000
- FY 2000 - \$53,450,000
- FY 2001 - \$55,545,000
- FY 2002 - \$39,935,000
- FY 2003 - \$11,450,000.

The basic building block of DOE's program to improve the safety of Soviet-designed reactors is the project. Each project has a clearly defined objective, a limited scope, a schedule and a budget.

The above budget projections are the time-phased funding needs of the program based on a summation of the project-by-project cost and schedule projections. These projections were prepared using a bottoms-up approach from the project level. To accomplish each program goal, projects were identified using the previously discussed selection criteria. The cost and schedule of future projects were estimated by considering accumulated program experience, known costs of ongoing projects of a similar nature, and expert judgement. Estimates of funding needed to complete existing projects were also determined, and actual data was used for completed projects.



## **Appendix F**

### **Evaluation of Information Exchange by Attendees**

**Contractor Information Exchange**  
**Improving the Safety of Soviet-Designed Nuclear Power Plants**

*February 19, 1997*

● **What is your overall evaluation of this session?**

4 Excellent    9 Very Good    2 Good    \_\_\_ Satisfactory    \_\_\_ Not very useful

● **Were your priority issues adequately discussed during the session?**

10 Yes, as much as I wanted

7 Would like to have heard more about [identify specific topics]:

More technical - less program (maybe personal preference).

Opportunities for U.S. companies.

News on what is currently going on.

Personnel issues in-country.

Jeff Ace's input to newly established "in-country" labor rates.

All ongoing projects - even if it's just a table.

Specific tasks: ISTC issues; relation of USIC Program.

● **Did you have an opportunity to participate as much as you expected?**

15 Yes, as much as I wanted

\_\_\_ No, not nearly enough    \_\_\_ No, not at all

☛ **Based on this meeting, what additional steps are needed?**

Dissemination of specific opportunities (research, contracting).

Would like to hear information about opportunities or need for activity work that my company may perform.

Repeat meeting on specific topics - for example, topical meetings on just safety or safeguards/security

☛ **How often should these Information Exchanges be held?**

9 Every 6 months    2 Every year    3 Other: 9 months = 2  
8 months = 1

☛ **How could we have improved this meeting?**

More opportunity for participant interaction.

Try to make it more experiential.

More active panel discussions.

I expected more dialog:

- How can PNNL get more support from contractor.
- What problems exist between DOE/PNNL/Contractors.

Warmer room.

More information on budget request and status.

Advertise more. Need more US participation by private company, NRC, DOE, etc.

● **Additional comments/suggestions:**

Well planned overall (timing & type of presentations).

Suggest an introduction overview to current activities throughout the INSP.

Should have had a summary of past meeting action items.

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