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Foreword

The Office of Environmental Restoration and Waste Management (EM) holds a unique position in support of the Department of Energy's mandate to restore the Nuclear Weapons Complex to an environmentally safe condition. The EM directive necessitates looking beyond domestic capabilities to technological solutions outside the boundaries of the United States.

The investment made by the United States in environmental restoration and waste management activities must be double-edged. That is, not only must taxpayer dollars be spent on site cleanup, but they must also help strengthen the national economy, particularly as it relates to the environmental industry. A stronger U.S. environmental industry can successfully deal in international markets, thereby improving U.S. competitiveness and better contributing to domestic technological development and application.

Our interactions with the former Soviet Union clearly illustrate this opportunity. The recent collapse of the Soviet government has made formerly restricted, elite Soviet scientific expertise available to the West. Cooperative technology development programs can mutually benefit both nations, each of whom are dealing with severe environmental problems.

It is the intent of *EM International* to describe EM's various roles and responsibilities within the international community. Cooperative agreements and programs, descriptions of projects and technologies, and synopses of visits to international sites are all highlighted in this semiannual journal. Reading *EM International* will hopefully broaden perspectives and initiate communications between those of us involved with these projects.

Clyde W. Frank
Deputy Assistant Secretary
Office of Technology Development
EM-50

Focus on EM Programs

International Collaboration in Vitrification Projects

by Bruce Kitchen

Vitrification is the approach used for the immobilization of high-level wastes in most countries that have nuclear programs. The 20-year period from 1985 to 2005 will see the development and hot startup (as shown below) of 10 or more major high-level waste (HLW) vitrification facilities worldwide. These projects represent a remarkable worldwide consensus in the proven borosilicate glass technology, which will provide safe, long-term disposal of the most radioactive of nuclear wastes.

Already, this has been a period of intense technology exchange as sponsoring agencies have established cooperative agreements, and DOE scientists have interacted with international colleagues in technology exchanges, on-site assignments, specialists' workshops, and cooperative research projects. These have advanced the DOE overall international exchange objectives of providing independent reviews of our programs; conserving DOE resources by incorporating foreign technology and by performing joint research; and ensuring U.S. views and policies are considered when international evaluations are conducted and international standards set.

The benefits of this international cooperation have been demonstrated many times in the past 20 years during research and development of the DOE vitrification program. For example, through the technology exchange on product testing and quality, we are assured that the U.S. program is developing tighter waste glass product specifications than the rest of the world.

Hot startups of major high-level waste vitrification facilities.

"Technical discussions at DOE-sponsored workshops and conferences and several peer reviews have disclosed significant technical detail about melter process dynamics, noble metals performance, and product quality/feed relationships."

Melter Design and Operation – Germany and Japan

Both the Germans and the Japanese have employed liquid-fed ceramic melters, which are essentially the same as those being designed and built for the DOE facilities (Defense Waste Processing Facility [DWPF], West Valley Demonstration Project [WVDP], and Hanford Waste Vitrification Plant [HWVP]). The hot startup of the German melter in 1985 at the PAMELA (vitrification) Plant has provided significant data and operating experience to confirm the same design for the U.S. programs. In addition to participation with German researchers over the years in many melter workshops, specialists from the DOE facilities have been on assignment at the PAMELA facility during hot operation and have applied lessons that have been learned while on-site, particularly those that occurred during off-normal operations. Technical discussions at DOE-sponsored workshops and conferences and several peer reviews have disclosed significant technical detail about melter process dynamics, noble metals performance, and product quality/feed relationships. The PAMELA melter is now in the disassembly and decommissioning stage, and DOE specialists are expected to learn more about erosion/corrosion characteristics of the ceramic insulation in this class of melters, along with other post-mortem secrets.

In Japan, the Tokai Vitrification Facility (TVF) is well into cold operations, and many of their lessons learned will be immediately applicable to the DWPF, now beginning its cold runs. Specialists from DOE facilities have been engaged for years with the Japanese in a continuing series of vitrification workshops under the bilateral agreements. In the last workshops at Tokai in November 1993, we learned that the Japanese are considering changes to their feed systems to increase waste loading and to improve product quality that could lead them into problems that may have serious impacts, similar to those that have just been solved in the DWPF. Our interest in maintaining the reputation of the borosilicate glass process will keep us involved with them on this problem. Serious consideration is being given to assigning a U.S. specialist to TVF during its final series of cold runs scheduled in the last half of 1993. The Japanese have had personnel assigned to each of the DOE vitrification research programs in years past, for periods up to two years each.

Melter Sensors – Germany

University and glass industry scientists in Germany have developed electrochemical sensors for controlling glass production. They have high potential for simplifying and improving the reliability of process control and waste glass certification in DOE vitrification melters. A researcher at the Savannah River Technological Center has established a joint research

project with Germany through Alfred University to obtain the design for the U.S. vitrification programs and to perform tests in the near future, both in Germany and at the DOE/Industry Center for Waste Vitrification at Clemson University. This project was jointly funded by the DOE and the National Science Foundation.

Operations Force Comparison – United Kingdom

Recently, DOE contracted with British Nuclear Fuels Limited, Inc. (BNFL), the principals at the United Kingdom's Sellafield Plant, to compare staffing requirements of the DWPF with those of the BNFL's Windscale Vitrification Plant (WVP) at Sellafield. The comparison focused on the operational phase of DWPF and identified two primary factors that contribute to the differences in staffing levels between the facilities. These factors include a very prescriptive approach to compliance with regulatory documents and the use of narrowly defined job descriptions. The recommendations of this comparison are now under study by the DWPF contractor. They represent a special category of benefits that are gained from international technology exchange, those of services under contract.

Acceptance Process – France

Another instance of a technical service contract in vitrification technology exchange was the purchase from the French of a report that provided extensive detail of their high-level waste glass acceptance and qualification program for the Atelier Vitrification de La Hague (AVH) facility. The DOE vitrification programs at Savannah River, West Valley, and Hanford have been jointly developing specifications for waste acceptance and qualifications for waste form. This effort is to ensure the vitrification product meets long-term disposal criteria in the proposed U.S. repository. In France, where spent fuel from French and foreign nuclear utilities is routinely reprocessed at the La Hague facility, vitrified HLW has been the subject of a similar waste acceptance process to satisfy French regulators. The extensive report of their technological studies and activities has principally given confirmation to our program, has provided a useful comparison with our acceptance process, and has raised issues for further study.

Waste Product Quality – Russia

Under the sponsorship of EM-50 a joint coordinating committee for environmental remediation and waste management (JCCEM) was established with representatives of the nuclear waste programs of the former Soviet Union. Vitrification was selected as one of the areas for technical exchange. In a recent workshop, a JCCEM research program has started in

"The DOE vitrification programs at Savannah River, West Valley, and Hanford have been jointly developing specifications for waste acceptance and qualifications for waste form."

which glass product samples from vitrification programs are exchanged. Each country will do product quality and leaching analyses, and the results will be compared. The Russian vitrification plants produce lead phosphate glass, but conversions to borosilicate glass are being considered.

Materials Interface Interactions Tests

Researchers at the Savannah River Technology Center and at Sandia National Laboratories have been cooperating with scientists from laboratories and universities in Germany, France, Canada, United Kingdom, Belgium, Japan, and Sweden in a vitrification product-testing program called the materials interface interaction test (MIIT). About 1,000 waste glass samples consisting of 15 waste glass compositions, 300 canister or overpack metal specimens, and more than 600 backfill and salt geologic samples were emplaced in actual salt repository conditions at the DOE Waste Isolation Pilot Plant in Carlsbad, New Mexico, for more than five years. More than 1,900 relevant interactions are being studied by combining leachant analyses with a variety of detailed surface analytical techniques. This program is one of the largest cooperative efforts ever undertaken in the international waste-management field and is producing a database that will benefit many programs in the DOE, and beyond.

Conclusion

During the next several years, DOE will begin radioactive operations at two major vitrification facilities (DWPF at the Savannah River Site and HWVP at West Valley). Successful startup and operation of these facilities will benefit greatly from the continued interaction with foreign efforts in vitrification. The lessons learned from the operation of these facilities and the technology enhancements that evolve may significantly help DOE facilities and programs. Continued support through these international collaborations, as described above, will continue to best support DOE vitrification efforts. ■

Bruce Kitchen, Jr.

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News in Brief

Bulgarian Waste Processing Facility Planned

The Scientific Ecology Group (SEG) is poised to be the first U.S. firm to build a radioactive waste-processing facility in a former Soviet country. A Western bank provided funding to Bulgaria. Funds will be transferred to vendors. The project at Bulgaria's Kozloduy nuclear power plant involves processing solid and liquid radioactive wastes, including 1-million gallons of liquid to be concentrated into a solid concrete matrix. A Bulgarian delegation will view an existing SEG facility at Oak Ridge, Tennessee, which will be disassembled and shipped to Bulgaria. The project has a 1993 completion date.

*Adapted from
World Environment
Report, 11/10/92,
p.194.*

Albanian Environmental Problems Identified

The Albanian Committee for Environmental Protection and the World Bank have completed the first study on the strategy of Albanian environmental protection. A main objective of this first stage is to produce a national environmental-protection plan with an overview of Albanian problems. Although environmental degradation is not as serious as in other East and Central European countries, such problems exist as erosion; the discharge of industrial waters; and air, water, and land pollution. Solutions will require new legislation. The second stage of the study is in process.

*Adapted from
Eastern Europe
Intelligence Report,
via NewsNet, 1/29/93.*

Bulgaria Establishes Environmental Infrastructure

New leadership at the Bulgarian Ministry of the Environment intends to set up a National Environmental Protection Agency, a national radioactive waste-protection system, and special emergency teams to respond to environmental incidents. This is according to a report presented by the Environment Minister to the Bulgarian Cabinet. Bulgaria's environmental-policy problems result from legislation and the lack of an overall concept of economic regulators, according to the Minister. National and municipal environmental protection funds are expected to be established soon. Bulgaria has signed 19 international conventions and agreements on environmental protection. The Ministry of the Environment will move six bills and 12 statutory instruments before the government by the end of the 1993 first quarter. The Environment Minister expressed dissatisfaction with non-observance of the Bulgarian-Romanian Convention on Environmental Protection of the common border.

*Adapted from
Eastern Europe
Intelligence Report,
via NewsNet, 1/14/93.*

German Technologies Ensconced in Bulgaria

Bulgaria and Germany have signed a five-year agreement on environmental cooperation, envisaging German financial, legal, and technical aid to fight pollution. Germany has already provided Sofia with two automatic air-monitoring stations costing more than 1-million deutsche marks (\$630,000 U.S.). The Bulgarian Environment Minister indicated that his ministry was exploring the possibility of diverting, for environmental protection, some repayments of the country's \$12 billion foreign debt, a move Germany would support. This diversion might finance Bulgaria's environmental projects. Germany is ready also to help upgrade safety at the Soviet-designed nuclear power plant at Kozloduy. Equipment worth \$20 million deutsche marks (\$12.57 million U.S.) has been supplied to Kozloduy from the former East German Greifswald nuclear plant, now shut down.

*Adapted from
Reuter News Agency,
1/30/93.*

German Funds Set for Environmental Clean-up

■ Financing to clean up contaminated sites in the former East Germany has been agreed upon. Private investors will pay 10 percent; remaining costs will be split 60/40 among Treuhandanstalt, the government's privatization agency, and state governments in the East. Spending will be limited to 1-billion deutsche marks (U.S. \$6 million) annually over the next 10 years. The agreement is retroactive to January 1, 1992.

■ Germany leads internationally in promoting research and development for environmental protection, according to a study by the Office for Economic Cooperation and Development (OECD). The study showed that between 1982 and 1992, the German Federal Government doubled total expenditures from 509-million deutsche marks (U.S. \$337 million) to more than 1-billion deutsche marks (U.S. \$663 million). The German Federal Ministry for Research and Technology, in Bonn, is responsible for 693-million deutsche marks (U.S. \$460 million). About half of this amount is available to research institutions outside the university arena. The other half supports project funding. Germany is responsible for 44 percent of government-financed environmental research in the European Community.

*Adapted from
International
Environment
Reporter, 11/4/92,
p. 706.*

*Adapted from
ATW News, 10/92,
pp. 5 - 6.*

- Federal funding of about 3-billion deutsche marks (U.S. \$2 billion) will be available until 1994 for cleanup of uranium-ore mining districts of the former WISMUT AG in Thuringia and Saxony. This is according to the German Federal Minister for Environmental Protection and Reactor Safety (BMU). During a September 1992 visit to the Ronneburg district, a region with 1,500 hectares to be cleaned, the Minister said the 1992 federal budget allotted about 986-million deutsche marks (U.S. \$650 million) for this purpose.

*Adapted from
ATW News, 10/92,
p. 7.*

Baltic to Assess Contamination to Marine Environment

The Baltic Marine Environment Protection Commission (also called the Helsinki Commission) will report the locations of chemical weapons dumped in the Baltic Sea after World War II and evaluate their consequences to the marine environment. The report should be available in 1994. The Commission represents the nine littoral countries, including Russia, Finland, Sweden, Denmark, Germany, Poland, Lithuania, Latvia, and Estonia, as well as delegates from the European Commission.

*Adapted from
Baltic Business
Report, 3/93.*

Scuttled Warships Concern Estonia

Dozens of warships scuttled by the Russian navy off the Baltic Coast could cause serious environmental damage to the region, according to the Estonian Minister of Environment. Recently, about 100 ships were sunk off the Estonian coast. Many were full of fuel; others may have contained dangerous chemicals. Any leaks could affect the entire Baltic area, the Minister said. Four to six tons of oil leaked recently from sunken military boats near the Russian naval base at Paldiski in northwestern Estonia.

*Adapted from
Stamm's XSU
Business, 3/15/93.*

European Community to Assist Poland

Poland is to receive 18-million ECU (European Currency Units) to develop an environmental policy, under a Polish-EC memorandum signed in Warsaw. The Polish Minister for Environmental Protection indicated the agreement would be funded through the EC "Phare" program and would support resource management and investment. Five million ECU of the allotment will help implement government environmental protection policy; 12 million ECU will support investment in selected projects, either as grants or as loans on a preferential and commercial basis. One-million ECU will be allocated for technical support.

*Adapted from
East Europe
Intelligence Report,
3/16/93.*

*Adapted from
Agence France-Presse
International News,
3/5/93.*

Soviet Military Cleanup in Poland

Cleaning up pollution on former Soviet army installations will cost Poland nearly 1 billion U.S. dollars, according to Polish officials referring to sites where fuel had seeped into the ground, threatening drinking water. Refurbishing buildings rented to ex-Soviet forces will cost an additional \$130 million. Under a bilateral agreement on the withdrawal of former Soviet troops, Warsaw and Moscow had effectively canceled their respective financial claims on each other. However, the Russian army must pay \$8 million for the past two years of troop deployment on Polish soil.

*Adapted from
Nuclear Waste News,
2/25/93, p. 73.*

Mayak Facility a Priority Threat

Russia's Mayak facility may be the world's foremost environmental concern, according to the Vice President of the Russian Academy of Sciences. It contains nearly every radioactive and hazardous waste. Radioactivity levels at the facility in the Chelyabinsk region are estimated at 9 billion curies, including high-level waste stored in above-ground tanks.

*Adapted from
Waste Tech News,
3/22/93, p. 6.*

Russian Nickel Plant Damages Forest

Russian giant Norilsk nickel plant has been fined 1.2 billion rubles (\$2 million U.S.) for polluting large areas of Siberian forest. The pollution has killed more than 350,000 hectares (880,000 acres) of forest. This is the first time the company will pay the fine; previous fines for ecological damage were paid out of the national budget.

*Adapted from
West Europe Intelligence Report,
3/23/93.*

Unserviced Ukraine Weapons a Potential Hazard

The Russian nuclear weapons in Ukraine could bring disaster, warned the Russian Defense Minister. Completely without servicing or maintenance, the weapons are becoming a major environmental problem, potentially larger than the Chernobyl disaster.

China, Columbia Expend Foreign Monies

- China received \$900 million during 1992 in foreign funds from the World Bank and the Asian Development Bank for environmental protection projects. The funds will be used to develop environmental protection plans in Beijing and Shanghai and the provinces of Liaoning, Shandong, Hebei, and Jiangsu. Information centers are being set up in Shanghai, Dalian, and Nantong. Two anti-pollution projects in Qingdao and Tangshan are in progress. A National Environmental Protection fund will be established at a cost of \$25 million U.S.
- In 1992, the Colombian government created Ecofondo, an environmental fund of domestic and foreign financial resources to support projects proposed by Colombian environmental groups. Colombian environmental protection officials from Inderena, the nation's environmental protection agency, and the National Department of Planning (DNP) supported creation of the fund to aid communication and environmental cooperation between government and non-government sectors. Ecofondo's objectives will be "to negotiate, receive, administer, and assign national and international resources to the nation's non-governmental organizations (NGOs) to undertake environmental projects." A general assembly of representatives from NGOs and a board of directors (five elected NGO representatives and directors of Inderena and the DNP) will administer Ecofondo. Officials are considering forming 12 committees, each to represent a region of the country and to define environmental priorities. The fund will start this year with \$0.5 million donated by the U.S. Government as part of a recent diplomatic agreement. The governments of Canada and the Netherlands may provide further funding, or Canada may forgive about \$18 million (Canadian) of debt if the Colombian government uses that money for Ecofondo.

*Adapted from
Xinhua English
Language News
Service via NewsNet,
1/18/93.*

*Adapted from
Environment
Watch: Latin
America, via
NewsNet, 1/93.*

*Adapted from
Reuter News Re-
ports, 3/29/93.*

Resources to Double for Middle East Program

The World Bank and other international aid agencies plan to double the size of a Mediterranean environmental program to foster regional cooperation in the Middle East. The Mediterranean Environmental Technical Assistance Programme intends to bring together Israel, Syria, and Lebanon to address common pollution problems. The World Bank, the European Community, the European Investment Bank, and the United Nations Development Programme will help fund the second stage. Slated for May 1993, it will last three years and cost \$30 million, twice that of stage 1. Germany and Switzerland may finance an organizational meeting, also in May. The multi-agency discussions resemble cooperative-environmental talks being held under the auspices of the Middle East peace process.

*Adapted from
Inter Press Service
International News,
3/10/93.*

Nairobi River a Health Threat to Kenya

The heavily polluted Nairobi River threatens animal and plant life. Previous cleanup attempts have been unsuccessful. A two-month University of Nairobi study found the river collects sewage, dust, scrap metals, peat, and other contaminants en route through the Kenyan capital of more than 1 million people. The river empties into the Athi River, where water is poisonous to human, animal, and plant life. The Athi River is the major source of fresh water 500 km away. No laws regulate disposal of industrial effluent into rivers. Kenya's national environment secretariat has no power to police environmental polluters. A permanent presidential commission on soil conservation and afforestation made no recommendations concerning the river.

*Adapted from
World Environment
Report, 3/2/93,
pp. 38 - 39.*

Free Trade May Cause Environmental Hazards for Mexico

Mexican health officials and environmental groups are concerned that the North American Free Trade Agreement (NAFTA) lacks enforcement standards to protect the health of Mexicans. A lack of infrastructure, funds, and expertise in Mexico make NAFTA environmental provisions impossible to enforce. In 1992, of 146 million metric tons of industrial waste, 5 million metric tons were hazardous. Only 1 percent could be confined in licensed hazardous-waste disposal landfills; the remainder was illegally dumped, burned, or discarded in sewer systems. High levels of pesticides have been reported in breast milk. Birth defects similar to those reported in border cities of Matamoros, and Brownsville, Texas, are common throughout Mexico.

British Radiation Leak Exceeds Proposed Limit

A radiation leak from the British Nuclear Fuels plc (BNFL) site at Sellafield released an estimated one gram of plutonium americium and uranium from a smokestack. The stack was in a reprocessing building being prepared for decommissioning. The release of about 1,000 mega becquerels (0.025 curies) over a 24-hour period did not exceed authorized safety limits and was just under one-quarter of the authorized annual limit of 4,300 mega becquerels (0.116 curies). However, the release occurred while BNFL is awaiting results from a United Kingdom Inspectorate of Pollution review of discharge limits. The release exceeds the proposed new limit. The increased dose to people living in the vicinity is estimated at 10 micro-Sv (1mR). The leak was the third in six months, but the first in which radioactivity escaped offsite. It was not reported for more than 24 hours.

*Adapted from
Nuclear Waste News,
2/25/93, p. 72; and
Nucleonics Week,
2/18/93, p. 9.*

Greenpeace Reports Aldermaston Deaths

More than 100 people have been killed or injured at the British atomic weapons facility at Aldermaston since 1955, according to a Greenpeace report. Fifty-eight accidents are said to have occurred, 33 of which were never publicly reported. The Greenpeace report provided details of seven work-place deaths and nine cases of cancer attributed to radioactive contamination. A 1978 report found buildings and surrounding areas of the waste-management complex were contaminated with radioactivity. Though that same report recommended structures be replaced as soon as possible, they are still in use.

*Adapted from
Nuclear Waste News,
2/11/93, pp. 54-55.*

Netherlands Plans for Jarosite Recycling

Authorities in Noord-Brabant province in the Netherlands have asked the Prime Minister to address problems resulting from storage of 2-million metric tons of zinc waste (jarosite) at the Budelco plant at Budel-Dorplein, near the Belgian border. Budelco contributes about 4 percent of the world zinc supply and generates about 120,000 metric tons of jarosite per year. In May 1992, Budelco began operating a biotechnological waste-water treatment process for removing of heavy metals. It has developed a pyrometallurgical process for jarosite and gypsum treatment, but considers this too expensive under the original plan. Instead Budelco proposes co-treatment of its wastes with those of third parties, using spent oil and waste oil (considered with jarosite as priority waste substances) as fuel.

*Adapted from
International
Environment
Reporter, 11/18/92,
p. 747.*

A proposed recycling facility will process 200,000 metric tons of jarosite; 12,000 tons of gypsum; 80,000 to 120,000 tons of water purification sludge (biomass); 20,000 to 30,000 tons of contaminated, dredged riverbed sand; 15,000 tons of zinc slags; 80,000 tons each of spent oil and waste oil; and possibly other heavy-metal-containing residues. (The Budelco jarosite is currently stored in three large basins. A fourth basin has been constructed, but Budelco cannot use it until the plant agrees to treat the jarosite waste. [Jarosite is a ferriferous waste containing zinc, cadmium, arsenic, and antimony.] In addition to jarosite, process waste water purification generates about 12,000 metric tons per year of heavy-metal-contaminated gypsum. The accumulated total since 1972 is about 400,000 metric tons, stored in two additional basins. The Budelco site is also heavily contaminated by zinc slags from a predecessor company.)

Japanese Plutonium Sent to Disposal Facility

*Adapted from
Nuclear Waste News,
11/12/92, p. 418.*

The Japanese vessel, Akatsuki Maru, took a controversial 17,000-mile, two-month journey last winter. The ship carried 1.7 tons of plutonium removed from spent Japanese nuclear fuel by Cogema (France's state-operated nuclear reprocessing company). Japan will use the plutonium to build a new generation of breeder reactor.

As the Akatsuki Maru traversed the Atlantic, some Japanese government officials expressed doubt about the planned 18-year shipment program. The plutonium shipment program has drawn domestic and international attention from countries along the possible routes. More than half the countries are known to oppose the ship entering their waters. Among them are the Philippines, Argentina, Chile, Brazil, and Peru. Concerns have ranged from addressing the potential for accidents causing plutonium leakage to concerns about hijacking by a hostile country with nuclear-bomb capabilities. To allay fears of terrorist attacks on the ship, the vessel was escorted by a Maritime Safety Agency ship, the Shikishima, equipped with firearms. A 24-hour operation center tracked the ship's location. The United States reviewed these plans and expressed no concerns. In addition, \$11.6 million were spent on rigging the vessel against accidents, natural disasters, and terrorist attacks. The multibillion-dollar program calls for Japan to ship 30 tons of plutonium from Europe by the year 2010. Plutonium is separated in Europe from Japanese nuclear waste originally sent to French and British reprocessing plants in the 1980s. As part of a 1991 Japanese government plan, the use of plutonium will be accelerated, and the use of uranium decreased for Japanese nuclear power. According to plan, the Akatsuki Maru will make three to four trips annually through 2010.

*Adapted from
International
Environment
Reporter, 12/2/92,
pp.772 -273.*

Japan Nuclear Fuel, Ltd. (JNFL) officially opened its \$1.28 billion U.S. low-level waste (LLW) disposal facility at Rokkasho on December 8, 1992. JNFL took 1,480 drums of LLW from Japan Atomic Power Co.'s Tokai nuclear power plant. The first batch of LLW was loaded at Tokai port on the special freighter Seiei-Maru on December 6. The Seiei-Maru transported the waste to Mutsu-Oawara port near Rokkasho. Another 6,520 drums of LLW (4,600 from Tokyo Electric Power's Fukushima 1 complex and 1,920 from Chubu Electric Power's Hamoaka station) followed before March. Construction of the Rokkasho LLW disposal site began in 1990. The site will eventually hold up to 3 million 200-liter drums of LLW. JNFL plans to bury 200,000 drums of LLW from all Japanese nuclear power plants by fiscal year 1998. Currently, drums are stored at each nuclear power plant site; the total number of stored drums has reached 550,000.

*Adapted from
Atoms in Japan,
12/92, pp 4-6;
Nucleonics Week,
12/10/92, pp. 8 - 9.*

Netherlands Institutes Environmental Legislation

A comprehensive Dutch environmental management law was expected to come into effect on March 1, 1993. The new law combines specific regulations for different concerns, including air and water quality, chemical and other waste, and noise pollution. The law will help industry by simplifying permit procedures, although it will also make environmental regulations easier to implement and enforce. Owners and operators of facilities required to have an environmental permit will generally deal with only one public authority; however, releasing substances into water will still require a separate permit. The new law requires permit authorities to periodically review the permits granted while considering the environment and technological developments. Every four years, the national and 12 provincial governments will outline an environmental policy plan with strategies for the next eight years. The national government will submit a new plan this year. In addition, national and provincial governments and individual communities are required to develop an environmental program detailing specific measures for the next four years plus annual updates. The environmental policy plans will include environmental quality requirements to be incorporated into regulations. Soon the new law may be expanded to provide better enforcement instruments and mandatory annual environmental reports.

*Adapted from
Environment Watch
Western Europe,
1/8/93, Vol. 2, No. 1.*

Finnish Firm Addresses St. Petersburg Pollution

The Finnish company, Outokumpo Ecoenergy, signed a three-year, \$75 million (U.S.) contract to build a chemical-waste treatment plant at Krasny Bor, near St. Petersburg. The land, water, and air around St. Petersburg are dangerously contaminated with industrial pollutants. These concern Russian and St. Petersburg authorities, as well as those in Finland. A joint cleanup is underway. Krasny Bor has a treatment plant, opened in 1970, to neutralize toxic chemical wastes. It was intended to operate three years, but instead became a waste dump for arsenic, fluorine, mercury, lead, cyanides, and phosphorus.

Finnish companies, with European Community (EC) assistance, are providing water purification facilities for the River Neva and Gulf of Finland. Both the river and Lake Ladoga (Europe's largest at 17,700 square kilometers and 230 meters deep) — St. Petersburg's main source of drinking water — are severely contaminated. They, in turn, pollute the Gulf of Finland. With urban growth and development of agriculture and industry, the amount of pollutants entering the water has increased from 271-million cubic meters in 1985 to 392-million cubic meters in 1988. Parts of the lake are eutrophied, and deterioration has been drastic since the 1960s. Mineral levels have increased by 18 percent, nitrogen by 28 percent, and phosphorus by 170 percent. Oxygen has decreased by 13 percent. Lake Ladoga is fed by the Volkhov River, which flows past the industrial centers of Novgorod and Kirishi. They discharge waste into its waters. It also flows through agricultural areas that use excessive pesticides and fertilizers. The lake has several pulp and paper plants on the northern shores. These cause severe contamination.

The biggest plant at Priorsk poured about 60-million cubic meters of waste into the lake, until it was closed as a result of public protest in 1988. Another paper plant at Svetogorsk subsequently tripled its discharge to 105-million cubic meters. The Syas paper mill dumps an additional 70-million cubic meters every year. Large amounts of sunken timber create other problems.

The result at the northern part of the lake is an increase in organic matter to 1.3 times the maximum permitted concentration (MPC). Lignin is five times the MPC and benzopyrene is 4.6 times the MPC. Sediments also contain sulfur, organic matter, oil, phenols, and pesticides. The River Neva is already polluted as it leaves Ladoga Lake toward the Gulf of Finland. The river acquires more pollution as it passes through St. Petersburg, where small tributaries join it. These first flow through the industrial suburbs where they pick up wastes. The Neva enters the Gulf via the Neva Bay.

With few water treatment facilities, St. Petersburg was discharging almost 90 percent of its sewage (untreated until 1985) into the bay. Although now reduced to less than 30 percent, levels of fecal bacteria in the bay still exceed MPCs by 100 times, and up to 10,000 times in the eastern part. The bay is contaminated also by waste and oil dumped from ships and port facilities. An estimated 10,000 tons of petroleum products are believed to be at the bottom of the Bay.

*Adapted from
Inter Press Service
International News,
via NewsNet, 1/21/93.*

Spanish Waste Storage Facility

The Spanish waste-management agency ENRESA has published a government decree authorizing operation of the second stage of the El Cabril low- and medium-level (LLW/MLW) radioactive waste-storage facility near Cordoba. It is in the southern region of Andalusia. This license inaugurates the first installation since the earlier El Cabril storage began in 1961. It was recognized as a radioactive installation, not as a nuclear installation. Like all other nuclear licenses in Spain, the El Cabril operating license must be reviewed for renewal every four years. Begun under the former Junta de Energia Nuclear (JEN, now CIEMAT), El Cabril was licensed in 1975. In 1986, control was transferred to ENRESA, which in 1989 authorized El Cabril to expand its capacity. The facility stores slightly more than 2,500 cubic meters of LLW and MLW. The expanded El Cabril site is similar to, but smaller than, the French waste-management agency ANDRA's Centre de Stockage de l'Aube (CSA). The Spanish model will hold 50,000 cubic meters of raw waste, while CSA can hold up to 1 million. Spain's Nuclear Safety Council requires the Spanish model to be able to later retrieve waste if necessary. (Drums will be placed in batches of 18 in concrete containers.) ENRESA has built a small factory to produce concrete containers at El Cabril, in addition to the more traditional compacting, incineration, and waste-package handling facilities. The El Cabril site includes a building for conditioning LLW/MLW from medical, industrial, agricultural, and research applications of radioisotopes. During the 300-year lifespan of El Cabril depot, the radioisotopes will have decayed sufficiently that the site can be returned to green-field status. ENRESA investments in El Cabril are about 10 billion pesetas (U.S. \$93 million).

*Adapted from
Nucleonics Week,
11/5/92, p. 17.*

Geotechnical Trade Fair and Congress

Some 20,000 environmental and geotechnical professionals will find a spectrum of technological applications. These include small mobile measuring units through complex information systems; and coordinated process technologies addressing key issues of geodetics, remote sensing, extraction technology, environmental and landfill technology; as well as cartography at the Geotechnica trade fair and congress. Geotechnica is to be held in Cologne, Germany, May 5-8.

Hyper-Accumulator Plants Cleanse Soil of Heavy Metals

The United Kingdom Agricultural and Food Research Council (AFRC) has developed hyper-accumulator plants to absorb heavy-metals from soil. These plants are reported to absorb up to 100 times more cadmium and 300 times more zinc from contaminated soils than other plants. An AFRC spokesman claimed the plants may eventually decontaminate soils. The research targets development of cost-effective soil decontamination. ■

*Adapted from
Pollution
Engineering,
3/15/93, p. 12.*

Technology Highlights

In Situ Sealing for Contaminated Sites

by Charles Voss

Golder Associates, Inc., in support of the International Technology Exchange Division (ITED), has identified several new materials for creating subsurface barriers in soils. The barrier materials are being developed in Europe to support cleanup efforts at contaminated sites primarily as a means for migrating contaminant transport before or during remediation. Two promising materials are (1) a mineral-wax dispersion developed in Germany and (2) a sodium-silicate grout developed in France.

Barrier technologies are an important component of the EM program for bringing all DOE facilities and sites into compliance with applicable laws and regulations for protecting public health and the environment. One relevant objective is to contain known contamination long enough to enable realistic planning, scheduling, and budgeting for final cleanup. Subsurface barrier materials may provide a means for creating, *in situ*, a barrier or containment system that prevents movement of contaminants until they can be safely and effectively removed. This approach is consistent with the DOE strategy for preventing potentially dangerous situations from advancing.

"One relevant objective is to contain known contamination long enough to enable realistic planning, scheduling, and budgeting for final cleanup."

Mineral Wax

The mineral-wax (or montan wax) sealant was developed by Mitteldeutsche Braunkohlenwerke AG (MIBRAG) in Bitterfeld, Germany. MIBRAG was responsible for all lignite coal mining in the former East Germany. Their coal reserves contain the world's largest deposits of mineral wax. Mineral wax is found in lignite deposits that are not far advanced in the carbonization process. The wax is a remnant from vegetation that existed millions of years ago in tropical climates where thick wax layers on the leaves prevented excessive water loss during periods of dryness. Mineral wax may come from fossil palms similar to carnauba palms; the plants contain a wax similar in physical properties to the mineral wax.

Only three or four deposits of mineral wax exist. German deposits are the largest. Mineral wax deposits in Germany have been mined for centuries, and MIBRAG's processing plant in Amsdorf has been in operation since 1922. Production of mineral wax in the United States is concentrated at Lone, Amador County, California. U.S. production is relatively small, approximately 10 percent of the amount produced by MIBRAG.

Common uses for the wax include release coatings for precision casting, shoe and floor polishes, water proofing, and lubricants. Environmental use of the wax evolved in Germany because of a large number of the old,

open-pit mines used for waste disposal by the chemical industry in the area. The Halle-Leipzig-Bitterfeld area is one of the most contaminated regions in Germany with observable health effects in some areas. A majority of the disposal sites are below the water table and local regional aquifers have been contaminated. Because of the large number of sites, containment technologies are sought to mitigate the problem and allow time for developing programs and performing remediation.

The wax dispersion contains approximately 83 percent water, 15 percent mineral wax, and 2 percent surfactant. Soil porosity determines the size of the wax particles

Grout Containment — Mineral Wax Sealant Process.

in the dispersion. A combination of processes can produce a narrow range of particle sizes. Subsurface barriers are created by drilling vertical or inclined boreholes around the contaminated region, then injecting sealant into the surrounding soil. As shown in the figure above, the spacing must be close enough for penetration fronts between adjacent boreholes to meet. Subsurface barriers are created when the wax particles are trapped in pore spaces in the soil matrix, thereby, reducing the permeability of the soil. Field studies in Germany have successfully formed vertical seals in unconsolidated soils between adjacent boreholes. Penetration distances up to 5 meters from the borehole have been achieved along with reductions in the hydraulic conductivity of the soil from 10^{-4} m/s to 10^{-9} m/s.

Mineral wax is composed of C-24 to C-32 carbon chain esters of long-chained acids and alcohols. The wax is classified as mineral wax (due to how it is produced), but is really a plant wax with similar properties. The wax is non-toxic. Domestic sources are approved for use as indirect food additives in adhesives, animal glues, defoaming agents, etc.

Sodium Silicate Grout

The second sealant being tested was developed by Société Française Hoechst (SFH). The French subsidiary of Hoechst Chemical Company in Germany developed the inorganic grout to strengthen granular soils during near-surface tunneling and for sealing selected zones in petroleum reservoirs. The sodium silicate grout has been used extensively in U.S. civil engineering applications and is approved by the National Environmental Policy Act (NEPA). It is manufactured in the United States at Hoechst Celanese in Charleston, South Carolina.

The silicon-based grout consists of various portions of a dispersive suspension of very fine silica particles, an acid-based hardener, and water. The mixture produces an amorphous, silicon-dioxide gel with between 5 to 10 percent solids. Properties such as viscosity and setting time can be varied by changing the formula. Viscosities as low as 5 cPoise and setting times of 48 hours are achievable and allow for good penetration of the grout in low permeability. Although the grout has been injected from boreholes for soil strengthening, the material has not been tested in the field as a barrier (shown above). However, laboratory studies demonstrate that hydraulic conductivity of unconsolidated soils could be decreased by five to six orders of magnitude after grout injection.

Grout Containment — Sodium Silicate Sealant Process.

Subsurface Barrier Test Program

Golder Associates, Inc., under contract to Sandia National Laboratories, has begun a three-year testing program to determine the suitability of the two sealant materials for DOE's containment needs. The program will resolve questions on: (a) the compatibility of the barrier materials with anticipated waste forms; (b) the ability to construct vertical and horizontal barriers over considerable distances; (c) the physical and hydraulic integrity of the barrier; and (d) the regulatory acceptance of the approach and technology.

Integrated Demonstration (ID) projects at Hanford Engineering Development Laboratory, Idaho National Engineering Laboratory, and Sandia National Laboratories are interested in the technology and are participating in the study. The IDs also provide possible access to new emplacement and monitoring technologies being developed as part of the demonstration projects. Technical staff from MIBRAG and SFH are looking at possible modifications to materials to match soil and contamination conditions at the DOE sites. Both companies have agreed to assist in transferring useful technologies to DOE.

The testing and demonstration program is using a phased approach including peer review and decision points. The first phase involves laboratory bench-scale testing to determine the range of soil conditions in which the materials can be used, the performance of the material during and after injection, and their compatibility with different waste forms. A regulatory assessment of the barrier materials also will be performed to ensure they comply with NEPA and other federal and state regulations. The second phase of the program will consist of single-borehole injection tests under field-scale conditions. These tests are to determine the penetration and performance characteristics of the barrier materials under actual conditions and to include monitoring the injection front and post-test characterization of sealant coverage and barrier performance. If the results are positive, the final phase involves a multiple-borehole test to demonstrate the feasibility of creating a continuous barrier over relevant field-scales (tens of meters). ■

Charles Voss

Charles Voss, an Associate with Golder Associates, Inc. in Redmond, Washington, is currently conducting foreign country surveys to identify foreign technologies and needs for the International Technology Exchange Division. He is the principal investigator for evaluating innovative subsurface barriers for the mixed-waste underground storage tanks at Hanford, Washington.

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Remote Sensors for Toxic Pollutants

by Robert J. Silva

Researchers at the Karlsruhe Nuclear Research Center (KfK) Germany, have developed expertise and instruments for the remote detection and quantification of toxic chemical species. They are using conventional absorption spectroscopy and laser-based photothermal spectroscopy. The Institute for Radiochemistry has identified four specific technologies: (1) laser-induced photothermal spectroscopies applied to remotely detect and characterize organics at a concentration range of 1-ppb or less; (2) internal reflectance spectroscopy used for remotely detecting organics and toxic metals at the 1-ppm level (see schematic); (3) optical sensors to detect heavy metals, e.g., Cd, Hg, and Pb; and (4) development of chem field effect transistors (FETs) and surface acoustic wave (SAW) devices for detecting specific pollutants.

Absorption spectroscopy methods are widely used and considered one of the most reliable techniques for detecting and characterizing solution species. However, conventional absorption spectrometers have sensitivity limits (ppm) usually above Environmental Protection Agency's maximum concentration limits (ppb) for actinides, organics, and toxic metals in uncontrolled sources of water. Within the past few years, new laser-based techniques have been developed to measure weak sample absorbency. These techniques — photoacoustic (PAS), photo-thermal deflection (PDS), and thermal lensing spectroscopies (TLS) — are referred to as photothermal spectroscopies. They are about 1,000 to 10,000 times more sensitive than absorption spectroscopy, using conventional spectrometers. Using photo-thermal deflection spectroscopy, the Karlsruhe group has obtained sensitivities of 1-ppb or less for several aromatic hydrocarbon-based pesticides. They have experience using optical fibers for transport of the laser beam over distances up to 100 meters. The Karlsruhe group has developed flow-through cells in combination with their PDS spectrometer. Sensors, based on the measurements of absorption spectra, would have a more

Schematic of an internal reflectance spectrometer for remote sensing for organics and toxic metals.

"Through an exchange of personnel, technology has been transferred between Lawrence Livermore National Laboratory (LLNL) and KfK."

general application; they could monitor several pollutants at the same time and would have an extended lifetime. Sensors based on photothermal spectroscopies have not previously been developed for remote monitoring of pollutants. Through an exchange of personnel, technology has been transferred between Lawrence Livermore National Laboratory (LLNL) and KfK. LLNL is currently developing a field sensor.

A large number of the metals and organics, considered toxic hazardous waste, have regulated levels in the ppm range. These pollutants in process streams could be monitored by absorption spectroscopy, using a commercially available standard absorption spectrometer and optical fibers. Such an instrument would be cheaper, more versatile, and more portable than the laser-based system currently used. In the field, the new technology could act as a rapid screening instrument for groundwater and liquid-waste containers. The Karlsruhe group has developed a flow-through cell for process stream monitoring using this instrument. More important, the Karlsruhe group has used this instrument and associated optical fibers to construct an Internal Reflectance Spectroscopy-based (IRS) instrument for the remote detection and characterization of toxic organics in the ppm range. The application of IRS to organic detection has been demonstrated by this group for trichloroethylene; 2,4 dichloroethylene; chloroform; and anthracene. By applying selective coatings to the fiber sensor, small amounts of organics can be isolated from the water environment with an increase in sensitivity. This is due to the elimination of the water background in the absorption spectra. The Karlsruhe group is also considering a variety of fiber-sensor coatings to selectively isolate and concentrate trace amounts of toxic metals from aqueous media. Technology was transferred to LLNL, and an instrument was successfully demonstrated in the field at LLNL and the Savannah River Site.

Through conventional absorption spectroscopy, the Karlsruhe group has also developed, for toxic metals (Cd, Hg, Pb), an optical sensor that could be produced economically. The sensor is composed of a plastic disk impregnated with a complexer specific for the metals. It can be placed in ground water and other aqueous media, where the toxic metals interact with the complexer. The disk can be scanned by absorption spectroscopy either *in situ* or after recovery from the water for the determination of the metal concentrations. A detection limit of 0.3 ppm was demonstrated for cadmium by the Karlsruhe group. The technology for this sensor was also transferred to LLNL and demonstrated at the Savannah River Site.

The researchers in the Institute for Radiochemistry at KfK are working with industrial partners to develop chem field effect transistors and surface acoustic wave devices for the detection of specific toxic materials, in both liquid and vapor phases. These devices can be quite small — the

size of a transistor — and mass produced. Ion-sensitive field effect transistor chips are being developed for measuring ion concentrations in aqueous solution. The measurement of pH is a common application; however, multiple array probes are sensitive to different ions in solution. The Karlsruhe group has demonstrated a four-surface acoustic wave sensor array with different organic vapor selective materials for simultaneous monitoring for methanol, ethanol, and propanol. Using several selective coatings, discrimination between different solvent vapors is possible by application of chemometric methods (pattern recognition). These devices usually have sensitivities greater than 1 ppm. The KfK group has initiated a vigorous research program in developing microsensors. The initial research effort has focused on studying the physical characteristics of acoustic wave devices and chem-field effect transistors in aqueous environments. Commercially available coated-surface acoustic wave sensors have been purchased for the detection of organic vapors in new buildings. Chem-field effect transistors technology has been tested with good sensitivity for iodine detection. The current research direction involves the deposition of an amorphous glass layer for the gate, to provide a sensor for sodium ions. The KfK is committed to developing these technologies for sensor applications and expects to have field-portable units within the two years. ■

Robert J. Silva

Robert J. Silva serves as Deputy Director at the Institute for Transactinium Science at Lawrence Livermore National Laboratory (LLNL). He has published more than a 100 contributions on actinide chemistry, chemical modeling, absorption and fluorescence spectroscopy, and ultrasensitive laser absorption spectroscopy.

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Profiles of Countries

Arctic Contamination by the Former Soviet Union

by Francis Y. Tsang

Following the demise of the Soviet Union, reports have alleged radioactive and hazardous-materials contamination in the Arctic Ocean and its surrounding seas. Official Russian statements indicate the radioactivity in these areas is confined to sites targeted for ultimate cleanup and disposal. Data obtained before the demise of the Soviet Union have proven useful, but information about Arctic contamination is preliminary.

To better understand the Arctic contamination issues, a description of the sources of radioactive and hazardous materials discharge is essential.

Radioactive and hazardous material discharges into the Arctic have four principal sources: nuclear weapons production complexes; atmospheric and underwater nuclear testing near the Arctic; ocean dumping; and waste disposal at Novaya Zemlya.

- ▲ Nuclear Test Sites
- ▲ Nuclear Storage Location
- ▲ RN Waste Dumping Sites

- ✂ Scuttled Submarines/Ships
- ✂ Submarine Base Locations

Areas of possible contamination in the former Soviet Union.

Former Soviet Union Nuclear Weapons Generation

The generation of radioactive and hazardous materials began in the late 1940s when the Soviet Union started its first nuclear weapons production at the Chelyabinsk nuclear production complex, about 1,000 miles southeast of Moscow in the Ural Mountains. Radioactive and hazardous-waste solutions from the complex were discharged into the Techa River, which flows into the Irtysh and the Ob rivers and ultimately enters the Ob Gulf (Obskaja guba) of the Kara Sea. The Ob Gulf is located several hundred miles east of the island of Novaya Zemlya. A similar Siberian facility, Tomsk-7, has been discharging

radioactive liquid wastes into the Tom River since the early 1950s. The Tom River also flows into the Ob River.

The Russians have stated that most wastes lie within the Techa and Ob River floodplain. Although there would be considerable dilution and sorption of the radioactive and hazardous materials en route to the Kara Sea, estimates of how much actually entered the Arctic are impossible without reviewing the official records and performing extensive characterization measurements. The map below shows the nuclear sites.

Atmospheric and Underwater Nuclear Testing

Nuclear weapons testing was conducted at Novaya Zemlya from 1955 through 1990 until a self-imposed testing moratorium was announced. Novaya Zemlya was a principal site used for atmospheric and underwater nuclear tests. The majority of tests occurred in two time-spans: 1957 to 1958 and 1961 to 1962. In 1962, the United States and the Soviet Union signed the Limited Test Ban Treaty, which prohibited nuclear weapon testing in the atmosphere, underwater, and in space. In general, atmospheric testing resulted in the transport of radioactive materials into the stratosphere where, diluted by wind and rain, they returned to earth within a year. These materials were distributed over the Northern Hemisphere, including the Arctic Ocean. Underwater nuclear weapon testing caused localized radioactive contamination, spread by ocean currents and marine animals. However, over time sea water dilution could effectively reduce radioactive concentration. During the 1950s and 1960s, the United States, the United Nations, and other governments published many reports on radioactive fallout from atmospheric and underwater nuclear weapons testing.

Locations of FSU Nuclear Complex

▲ Nuclear Submarine	◆ Nuclear power reactor
● Nuclear Submarine Base	▼ RN waste-dumping sites
● Nuclear Submarine Base	Highly Contaminated Rivers
RN Contamination	

Nuclear facilities in the former Soviet Union.

"The Swedish news agencies also reported that at least 13 nuclear reactors were dumped in the Arctic waters, ten of them three bays east of Novaya Zemlya. Three of the reactors came from the icebreaker Lenin, while others presumably were from scrapped nuclear submarines."

Ocean Dumping

Andrey Zolotkov, a former deputy to the Supreme Soviet from Murmansk, announced last year that the Soviet Union practiced ocean dumping of hazardous and highly radioactive wastes in the Barents and Kara seas from 1964 to 1986. According to Zolotkov, 10,250 containers, each one-cubic-meter in volume, were dumped into Arctic waters at a depth of 20 to 400 meters. Containers that did not readily sink were punctured by bullets. In addition, a variety of hazardous and nuclear wastes were reportedly dumped in the Novaya Zemlya trench. A cargo vessel with a damaged nuclear reactor, 1,450 containers of radioactive waste, and a tanker with highly toxic liquid wastes are some examples.

The Swedish news agencies also reported that at least 13 nuclear reactors were dumped in the Arctic waters, ten of them three bays east of Novaya Zemlya. Three of the reactors came from the icebreaker Lenin, while others presumably were from scrapped nuclear submarines.

Waste Disposal at Novaya Zemlya

Recent Russian and Western documents report that Novaya Zemlya and its shallow bays were used as disposal sites for much of the wastes generated by the Soviet naval nuclear program. The following presents a partial listing:

1. Tsiolki Bay — 4,750 containers of radioactive wastes, the lighter N. Bauman, the mid-section of the icebreaker Lenin with three damaged reactors.
2. Oga Bay — 850 containers of radioactive wastes.
3. Stepovogo Bay — 1,850 containers of radioactive wastes and a damaged nuclear submarine containing two reactors with fuel still inside.
4. Abrosimov Bay — 550 containers of radioactive wastes and sections of four damaged nuclear submarines (a total of eight reactors, three containing nuclear fuel).
5. Blagopolchiya Bay — 650 containers of nuclear wastes.
6. Teheniy Bay — a damaged reactor without nuclear fuel.

The former Soviet Union has excluded foreigners from access to Novaya Zemlya and to date, the Russian government is continuing this policy. The above information must be viewed as unconfirmed, and any description of radioactive and hazardous wastes must be considered as uncharacterized.

EnviroTRADE Facilitates Data Exchange

Currently, EM-50 has an ongoing program called Environmental Technologies for Remedial Actions Data Exchange (EnviroTRADE). EnviroTRADE is an international information system. It facilitates the exchange of environmental restoration and waste management technologies. This system contains both foreign and domestic technologies and needs profiles. A matching algorithm finds applicable technologies for environmental problems, and conversely, finds environmental problems where a technology might be applied. It also provides general information on international environmental restoration and waste management organizations, sites, activities, funding, and contacts. EnviroTRADE uses a graphical user interface architecture to display information via single entry or multilayered windows. EnviroTRADE also displays geographical information through its geographical information system (GIS) capability. It is our intention to use the EnviroTRADE system to build an Arctic contamination profile database. This database should optimize both Russian and Western environmental reports. ■

Francis Y. Tsang

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EM Activities With Germany: Cooperative Arrangements

by David W. Geiser

"... the United States shared melter technology with Germany; Germany shared repository technology with the United States."

DOE-EM and its predecessors have cooperated with the Federal Republic of Germany (FRG) in the area of radioactive waste-management. This cooperation officially began in December 1974 when the Atomic Energy Commission and the BMFT (Federal Ministry for Research and Technology) for Cooperative Radioactive Waste Management Technology Exchange signed an umbrella bilateral agreement. The agreement addressed geologic disposal in salt deposits, retrievable surface storage, decontamination and decommissioning, transportation, and operational aspects of low-level waste (LLW) and intermediate-level liquid waste (ILW) storage and disposal. After several amendments and extensions, the DOE/BMFT bilateral agreement expired in June 1991. DOE and the BMFT are re-initiating the agreement, which will include revised provisions for intellectual property rights.

A project agreement on Methods of Treatment for Immobilization of High-Level Radioactive Waste is included under the auspices of the DOE/BMFT umbrella bilateral agreement. The project agreement was signed November 1984 and officially expired November 1990. It allowed the Hanford site to make 30 vitrified glass canisters for shipment and subsequent repository testing in Germany. Under this agreement, the United States shared melter technology with Germany; Germany shared repository technology with the United States. Although the project agreement officially expired two years ago, it is still in effect through a continuation clause because the project has not been completed.

Activities in Fiscal Year 1992

EM sponsored an effort to identify and evaluate EM-related German technologies in fiscal year 1992. Golder Associates Inc., through Sandia National Laboratories (SNL), provided a German survey report titled "ITEP: A Survey of Environmental Needs and Innovative Technologies in Germany." Golder will continue this survey of German technologies during fiscal year 1993.

Another EM effort with Germany was coordinated in December 1992 by Oak Ridge National Laboratory (ORNL) and resulted in the signing of a Cooperative Research and Development Agreement (CRADA) with Ogden Environmental Services Company, Inc., of Fairfax, Virginia. The CRADA supports the development and testing of a bioremediation technology to remove uranium, arsenic, and other metals from waste

streams. Ogden's German subsidiary, Ogden Umwelt and Energie, will demonstrate this three-year technology exchange at a site in Eastern Germany. The demonstration is a cooperative effort with WISMUT, the former operator of uranium mines. This technology promises a cost-effective solution for U.S. and German sites that are contaminated with uranium and heavy metals. EM-541 manages the project.

In 1992, EM participated in a project for the *in situ* destruction of organic compounds. This project was jointly executed by ORNL, the Savannah River Site (SRS), the German BMFT, and the University of Karlsruhe. The objective of the project was to develop a process/mechanistic understanding of *in situ* bioremediation and advanced oxidation of aliphatic and aromatic hydrocarbons. Laboratory and field experimentation at the Karlsruhe site was combined with follow-on work and technology transfer at U.S. DOE sites. This project, initially supported by EM-523, was completed in fiscal year 1992, and the results were transferred to EM-541.

EM initiated a project in 1992 involving *in situ* sealing of contaminated sites. Golder Associates Inc. and SNL executed the effort. The project used two German sites to evaluate the effectiveness of horizontal boreholes in characterizing sites the German government planned for subsequent remediation. The two sites, the Chemie Bitterfeld/MIBRAG (Mitteldeutsche Braunkohlenwerke AG) site located near Leipzig, and the Munchenhagen site northeast of Hanover, are contaminated with DNAPLS (dense non-aqueous phase liquids). They were to be tested for the feasibility of injecting polymers through horizontal boreholes into the formation to form a seal below the contaminant plume. Sealant material used by Germany in this project is currently being reviewed by EM-541 for application in the *in-situ* remediation Integrated Program.

Also in 1992, an EM project on remote sensors for organics, toxic metals, and actinides was carried out by Lawrence Livermore National Laboratory (LLNL), SRS, and Karlsruhe Nuclear Research Center. This project investigated and developed several laser-based spectroscopic methods using optical fibers for the remote sensing of organics, toxic materials, and actinides in environmental and process-stream situations. Because the Karlsruhe group is considered competitive with the United States in the development of several laser-based sensors, LLNL studied how applicable these techniques are to DOE problems. There were also efforts to develop instruments for field tests at Karlsruhe, Germany; at the Mixed Waste Landfill Integrated Demonstration at SNL; and at the Volatile Organic Compound Integrated Demonstration at SRS.

"An EM effort with Germany...resulted in the signing of a Cooperative Research and Development Agreement with Ogden Environmental Services Company, Inc.... The (agreement) supports the development and testing of a bio-remediation technology to remove uranium, arsenic, and other metals from waste streams."

"Former EM Assistant Secretary Leo Duffy led a delegation in November 1991 to Karlsruhe, Gera, Braunschweig, and Hamburg. The group discussed and evaluated joint DOE-EM/German environmental restoration and waste-management projects. They identified new technologies and opportunities for collaboration."

Travel

DOE-EM headquarters, field, and contractor staff have traveled to Germany on several occasions to attend conferences and to explore additional areas of cooperation. Former EM Assistant Secretary Leo Duffy led a delegation in November 1991 to Karlsruhe, Gera, Braunschweig, and Hamburg. The group discussed and evaluated joint DOE-EM/German environmental restoration and waste-management projects. They identified new technologies and opportunities for collaboration. More recently in July 1992, Deputy Assistant Secretary for Environmental Restoration R. Pat Whitfield led a delegation to Germany to explore areas of possible technology exchange in the field of environmental restoration. A goal was to determine the scope of German remediation of uranium mining and milling facilities operated by the East German government for the Soviet Union during the cold war. The delegation also sought to identify potential areas for a reciprocal exchange of information, equipment, and/or personnel to the mutual benefit of U.S. and German national environmental programs. As a result, DOE-EM is pursuing an umbrella bilateral agreement with the German Federal Ministry for Environmental Protection and Reactor Safety and the Federal Ministry of Economics. The agreement will address environmental restoration.

Future Cooperation

In fiscal year 1993, the Hazardous Waste Remedial Action Program (HAZWRAP) will coordinate fulfilling Department of Defense (DoD) needs in Europe with finding innovative European technologies for DOE facilities. Also HAZWRAP will demonstrate U.S. technology in the European market. The task involves developing one or more DoD and DOE joint technical demonstrations that could lead to international Integrated Demonstrations at DoD foreign installations. HAZWRAP will investigate U.S. Army bases in Germany to determine the environmental requirements to bring these sites into compliance. In addition HAZWRAP will review treaties, agreements, laws, and regulations required for environmental remediation and demonstrations. Also HAZWRAP will coordinate efforts for a joint meeting with the International Technology Exchange Division and Headquarters U.S. Army in Germany. To accomplish this, EM has placed a contractor in Germany.

DOE-EM is the co-sponsor of the Fourth International Karlsruhe Nuclear Research Center and Netherlands Organization for Applied Scientific Research Conference on Contaminated Soils. The conference (held on May 3 - 7, 1993, at the International Congress Center in Berlin, Germany)

addresses the problem of soil and groundwater contamination caused by human activities. This issue is recognized as a major environmental problem in most countries worldwide. At the time of this writing, approximately 2,000 foreign and U.S. attendees are expected to attend.

This article provides a sample of DOE-EM interactions with Germany. As the central coordinator of international activities within EM, we request information from other EM offices cooperating with Germany (as well as with other countries) on projects, in conferences, or during on-site visits. ■

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Technology Transfer Activities

Environmental Technology Export Council: Expanding U.S. Environmental Exports

by Thomas A. Page

"The world market for environmental technology is presently at \$300 billion annually and is expected to reach \$600 billion by the year 2000. The Environmental Technology Export Council (ETEC) was formed to help coordinate a national program to enable American environmental technology companies compete more effectively in the international marketplace."

Increasing global demand for environmental technology represents a potential growth market for American business. The world market for environmental technology is presently at \$300 billion annually and is expected to reach \$600 billion by the year 2000. The Environmental Technology Export Council (ETEC) was formed to help coordinate a national program to enable American environmental technology companies to compete more effectively in the international marketplace.

The U.S. environmental industry now meets domestic needs, but the industry requires assistance in meeting the global demand. The challenge is to create new jobs and boost the economy within the United States while increasing environmental technology exports globally. ETEC intends to meet this challenge.

ETEC is an organization of U.S. corporations, national laboratories, and trade associations. Its purpose is to stimulate the export of U.S. environmental goods and services. A non-profit business association as defined by Section 501 (c) 6 of the Internal Revenue Code, ETEC includes more than 44 corporations, eight federal laboratories, and three trade associations. Early in 1992, a nationwide organizing committee chose Thomas A. Page, Chairperson and CEO of San Diego Gas & Electric, to be the first ETEC Chairperson.

The participation of most DOE multiprogram laboratories is a vital factor in ETEC's success. The DOE labs represent a critical link between the public and private sectors, particularly in technology transfer. Member labs include Argonne, Idaho National Engineering, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, Pacific Northwest, and Sandia National Laboratories. Corporate members represent companies of all sizes and sectors of the environmental business community. Some are large multinational firms with full-service capabilities, and others are small consultant groups. Hazardous waste and bio-remediation firms are also well represented. Other members have historically focused on defense-oriented work, but as the post-cold-war era progresses, an

increasing part of their work is environmental. Financial institutions in the private sector also play a key role in ETEC. The financing of international environmental projects must be carefully managed if U.S. environmental firms are to be successful overseas.

Trade associations bring to the Council their experience in dealing with environmental companies, along with knowledge of government relations. Members include the Air and Waste Management Association, the U.S. Export Council for Renewable Energy, and the American Gas Association, along with others.

ETEC objectives are based on two principles. First, two decades of U.S.-developed technology for environmental restoration has created one of America's most internationally competitive industries with the greatest potential for growth. Second, as other nations enhance their environmental quality and upgrade their environmental technology, opportunities will emerge for America to supply the rest of the world with state-of-the-art technology at competitive prices.

The Council plans a number of programs to address the growing business of controlling air, water, and ground pollution. These programs include cooperation between federal agencies, the national laboratories, and the private sector; financing programs to support exports into developing regions of the world; and giving members access to a U.S.-based team of experts, who can assist in business development.

The ETEC 1992 Fall Conference in Washington, D.C., was a productive step. Speakers from a variety of organizations addressed how ETEC can work with federal agencies, financial institutions, and foreign government affiliations.

ETEC was pleased to have such strong support from a number of federal agencies, including the Department of Energy. Gary Voelker, principal assistant deputy assistant secretary for the DOE Office of Technology Development, addressed the many opportunities for cooperation between ETEC and DOE.

Representatives from several other federal agencies participated as well. The U.S. Agency for International Development, the Department of Commerce, the Department of Defense, the U.S. Environmental Protection Agency, and the Overseas Private Investment Corporation all made outstanding contributions. ETEC is continuing its close contact with these agencies for future coordination.

"... two decades of U.S.-developed technology for environmental restoration has created one of America's most internationally competitive industries with the greatest potential for growth."

ETEC received tremendous cooperation from the government of Mexico in planning and implementing the conference. Mexico is a critical trading partner of the United States, and environmental concerns have come to the forefront of the discussions concerning the North American Free Trade Agreement. Officials from the Mexican ministries of industry and the environment have noted that the ETEC conference enhanced environmental business cooperation between the United States and Mexico.

Financial institutions also made strong contributions to the conference. The International Finance Corporation, the U.S. Export-Import Bank, the Nacional Financiera State Development Bank of Mexico, and several significant private institutions discussed ways for financing international environmental projects. ETEC is hoping this cooperative spirit continues to grow between all parties; U.S. environmental technology industry is poised to make a significant contribution to the strengthening of the U.S. economy. ETEC aims to make U.S. environmental technology more competitive.

Companies in the environmental technology market have known for decades what others are just now finding out — that the United States holds a comparative advantage in environmental products and services; the worldwide demand for environmental technology is so great that the industry is sure to play a critical role in U.S. economic growth. ■

Thomas A. Page

Thomas Page is the Environmental Technology Export Council Chairperson. Page has led San Diego Gas & Electric (SDG&E) since 1983; he chairs the boards of both of SDG&E's non-utility business corporations, Pacific Diversified Capital and Wahico Environmental Systems. Since joining SDG&E in 1978 as executive vice president and chief operating officer, Page has served as president and chief executive officer, and in 1983 the board of directors elected him chairperson.

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International Technology Transfer: Are the Opportunities There?

by Ivy V. Schram

Increasingly, U.S. companies are eager to explore opportunities to introduce innovative environmental technologies to the international market. The need for such technologies is enormous — especially in the European Community where the public, industry, and regulators share a renewed concern about resolving the problems caused by four decades of Communist rule and rapid industrial expansion.

Throughout Europe and in the former Soviet Union, a strong demand for equipment can be used to *prevent* multimedia pollution in both the short- and long-term. According to a recent article in *The Philadelphia Inquirer*, this trend is likely to increase at 50 percent a year for the next 10 years. Options to address widespread deterioration of air, water, and soil also will be necessary.

Despite the overwhelming need for new technology, many companies are reluctant to enter the international market due to the myriad of political, social, legal, technical, business, and economic barriers that impact technology transfer.

One problem is the array of regulations and enforcement policies found in individual countries. Germany, for instance, has passed stringent recycling regulations that pressure business to minimize waste. A serious radioactive contamination and disposal problem — due to Chernobyl — exists in Eastern Europe.

Accordingly, individual countries and entire regions have specific priorities. The former Eastern block as well as the European Community will need to work together toward a common resolution and solution. In the meantime, however, diverse priorities can cause uncertainty.

Another key issue that affects technology transfer is the changing political situation worldwide and the unfavorable economic conditions it has fostered. Many countries do not have funds to develop or purchase technologies. Because most companies consider profit when entering the international arena, careful planning is required to identify opportunities that may prove financially rewarding.

"Despite the overwhelming need for new technology, many companies are reluctant to enter the international market due to the myriad of political, social, legal, technical, business, and economic barriers that impact technology transfer."

A number of public and private organizations in the United States are creating programs to help developers overcome these issues. The U.S. Agency for International Development (U.S. AID) in Washington, D.C., for instance, is heading a multimillion dollar project to bring environmental technologies to five Eastern and Central European countries. One of the main project activities will be a series of nationwide seminars to educate the U.S. business community about opportunities abroad and at helping the business community understand and overcome common barriers. Project participants include the National Environmental Technology Applications Corporation (NETAC), Sanders International, and Mathtech, Inc.

The Pittsburgh-based NETAC, created through a cooperative agreement among the U.S., EPA, and the University of Pittsburgh in 1988, also offers a variety of services to help environmental technology developers bring new technologies to national and international markets. These include regulatory analyses, environmental training, country-specific environmental industry, and market penetration strategies.

U.S. federal laboratories are another source of assistance. While these labs develop and use new environmental technologies for Department of Energy sites, they work also to bring these innovations to the commercial market place.

In any case, the key to success in entering the international environmental market is quick action — before the window of opportunity closes. ■

Ivy V. Schram

Ivy Schram is the Vice-President and Legal Counsel and Director of the Regulatory and International Programs at the National Environmental Technology Applications Corporation.
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International Organization Activities

International D&D Information and Technology Exchange

by William E. Murphie

Through participation in activities of the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) and through bilateral agreements with individual countries, the Office of Environmental Restoration is working with the international nuclear community to exchange information and technology on decontamination and decommissioning (D&D). William Murphie is the U.S. representative for the OECD/NEA participation, and the Chairperson of the D&D Technical Advisory Group (TAG) of that international body. The TAG meets twice a year at various locations in member countries, often near the site of a D&D project included in the TAG area of interest.

The last meeting took place in Rome in late October 1992, when the group visited two Italian D&D projects. The gatherings usually combine site visits with the TAG meetings and with meetings of related working groups on special topics of limited duration. The current active working group is a Task Group on Recycling and Reuse (TGRR). Its charter calls for preparing a comprehensive report on the potential for recycling and reuse of radioactive materials, with emphasis on metals. The United States will contribute a chapter to this report on the environmental and social-political impacts of recycling. Completion is targeted for 1993. Other special working groups in the past have addressed such subjects as decommissioning cost analysis and comparison. A future special task group will focus on decontamination.

The TAG works under the guidance of the Liaison Committee of the OECD, made up of representatives from the various member countries. The group carries out special studies and monitors specific international D&D projects as the working arm of the Liaison Committee. In October, the Liaison Committee approved two new power plant projects, one in the Slovak Republic, and one from the former East Germany, for inclusion in the TAG program. This brings to 21 the number of completed and active

The current active working group is a Task Group on Recycling and Reuse (TGRR). Its charter calls for preparing a comprehensive report on the potential for recycling and reuse of radioactive materials, with emphasis on metals.

projects now under the auspices of the OECD/NEA Technical Exchange Cooperative Agreement in the TAG area of attention. Two active U.S. projects are included: the Experimental Boiling Water Reactor (EBWR); and the West Valley Demonstration Project. The Shippingport Station Decommissioning Project (see photograph) is the completed U.S. project under the TAG.

Each TAG meeting features reports on active projects in the program. Such reports form an excellent basis for the exchange of technical information. Recent reports have dealt with real-world, hands-on aspects of such technical topics as the following:

- Diamond-wire cutting of concrete walls;
- Use of remotely operated equipment for sampling, monitoring, and dismantling operations;
- Examples of efficient use of robotics;
- Abrasive water-jet cutting of biological shields;
- Underwater mechanical milling to segment heavy-metal components;
- Use of linear explosives to segment storage tanks.

The need for new special studies and the inclusion of new D&D projects are regularly reviewed by the Liaison Committee and the TAG. Contacts are being made with the Commission of the European Communities to assess their interest. There are some unique U.S. commercial D&D efforts that might fit the program. One technical issue that is frequently discussed, and of great interest to the United States, is the establishment of internationally accepted free release standards for materials with minuscule quantities of residual radioactivity. Some countries — France is a principal example — have established criteria and are working to implement them. The United States still lacks a consensus; and the International Atomic Energy Agency, has yet to publish standards.

Metal melting and reuse experiences warrant frequent discussion at the TAG meetings. The French have reported success at Marcoule with the melting of large quantities of carbon steel pipe without previous decontamination. An electric arc furnace is used. The metal is reused for waste containers and for shield blocks. The United Kingdom is recycling aluminum. The EM-40 staff sees great benefit in establishing a workable means of decontaminating and reusing metal scrap from D&D projects.

An interesting philosophical difference between nations was discussed at the meeting in Rome. The United States tends to treat remediation of soil and groundwater as issues different from D&D, which focuses on structures, equipment, and supporting systems (i.e. piping). Other countries treat soil and groundwater contamination as just one of the peripheral aspects of D&D. The current feeling among TAG members is that this difference in approach does not warrant special note or consideration in OECD/NEA activities.

An example of bilateral exchange activities independent of the OECD is the Japan Atomic Energy Research Institute (JAERI) agreement with DOE for sharing experiences in D&D projects. From the Japan Power Demonstration Reactor decommissioning project, DOE has received JAERI reports and technical information on cutting technologies using plasma arc saws and on the use of shaped charges for piping segmentation. In turn, JAERI has sent personnel on a short-term basis to the Shippingport and Experimental Boiling Water Reactor D&D projects for observation and contributory work assignments.

The variety of approaches and techniques in the D&D arena makes sharing real field experiences vital. Successes and failures can then be analyzed for lessons to apply elsewhere. One avenue for this exchange and transfer of experiences is participation in international groups of the type described here. ■

William E. Murphie

William E. Murphie is the Chairperson of the D&D Technical Advisory Group. Within the EM program, he is the Headquarters Division Director for the Oak Ridge Environmental Restoration Program. He was Program Manager for the Nuclear Energy Surplus Facilities Management Program prior to the formation of the EM program. He represents the U.S. as a member of the OECD/NEA Liaison Committee.
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Upcoming Events

DATES/PLACES	SPONSORS	SUBJECT	
May	British Nuclear Energy Society	(O) International Conference on Remote Technology	F. Bindon, P.O. Box 22, Bangor, Gynedd LL59 5QU, Wales, UK, TEL: 0248 71 33 30
May 2-7 Atlanta, GA		(O) 1993 International Conference on Robotics and Automation	
May 3-7 Knoxville, TN	University of CA-Irvine/ANS	(O) 12th Annual Incineration Conference	C. Baker, University of California, Environmental Health and Safety, Irvine, CA 92717, TEL: 714-856-7066, FAX: 714-856-8539; R. Kagel, DOW Chemical, TEL: 517-636-2377; E. McDaniel, ORNL, TEL: 615-574-0439
May 9-13 London, UK		(O) International Environment '93; Analysis '93; Water Waste and Recycling '93 Exhibitions	
May 10-13 Stratford-Upon-Avon, UK	British Nuclear Energy Society	(O) 2nd International Conference on Remote Techniques for Nuclear Plant	S. Trye, Ins. of Civil Engineers, Great George Street, London SWIP 3AA, UK, TEL: 071 839 9801
May 25-27 Washington, DC		(O) Federal Environmental Restoration 1993	
June 13-18 Denver, CO	A&WMA	(C) 86th Annual Meeting and Exhibition	L. Bradley, Technical Programs Systems Operator, Air & Waste Management Association, Three Gateway Center, 4 West, Pittsburgh, PA 15222
June 14-18 Avignon, France	ANS/ENS	(O) Safewaste '93: The Final Disposal of Nuclear Waste

		SUBJECT	MEETING CONTACT
June 20-24 San Diego, CA	ANS	(C) Annual Meeting of the American Nuclear Society	Meetings Department, American Nuclear Society, 555 N. Kensington Ave., La Grange Park, IL 60525, TEL: 708-352-6611, FAX: 708-352-6464
		(O) 14th International Seminar on Environmental Assessment and Management	TEL: 0224-272483/272480
Aug. 17-20 Baltimore, MD	ASHE/DOE/EPA/ U of Maryland	(O) Second International Mixed Waste Symposium	TEL: 410-706-7845
		(O) 3rd International Symposium on Separations Technology	M. Stalmans, University of Antwerp (UIA), Department of Chemistry, Universiteitsplein 1, B-2610 Wilrijk, Belgium, TEL: 32-3-820 23 75, FAX: 32-3-820-23 74
Aug. 23-27 Kirkenes, Norway		(O) International Conference on Environmental Radioactivity in the Arctic and Antarctic	K. Thumen, National Ins. of Radiation Hygiene, P.O. Box 55, N-1345 Oesteras, Norway, TEL: 472-24-41-90, FAX: 472-24-74-07
		(O) American Nuclear Society Topical Meeting on Environmental Transport and Dosimetry	R. Addis, Program Chair, Westinghouse Savannah River Co., Savannah River Technology Center, Bldg. 775-A, Aiken, SC 29808-0001, TEL: 803-725-3325, FAX: 803-725-4233
Sept. 5-11 Prague, Czechoslovakia	ASME/ C&SMES/ C&SNS	(O) '93 International Conference on Nuclear Waste Management and Environmental Remediation	E. Lung, American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017-2392; R. Kohout, Ontario Hydro (H11 A20) 700 University Ave., Toronto Ontario, Canada M5G 1X6, TEL: 416-592-5384, FAX: 416-592-4485
	ANS	(O) Global '93: Future Nuclear Systems-Emerging Fuel Cycles and Waste Disposal Options	J. Rawlins, Global '93 Technical Program Chair, Westinghouse Hanford Co., P.O. Box 1970, LS-55, Richland, Washington 99352, TEL: 509-376-5816, FAX: 509-376-9964
Sept. 19-24 Bath, United Kingdom	U.S. DOE	(O) 1993 International Symposium on Subsurface Microbiology	L. Hide, Conference Organizer, IBC Technical Services, Ltd. Tilmoora House, 57-61 Mortimer St., London WIN 7TD, TEL: 44-71-637-4383

DATES/PLACES	SPONSORS	SUBJECT	
Sept. 20-24 Makuhari/Chiba	JAERI	(O) Seventh International Conference on Emerging Nuclear Energy Systems	Dr. T. Hiraoka, ICENES '93, Department of Reactor Engineering, JAERI, Tokaimura, Ibaraki-ken, 319-11 Japan, TEL: 81 292 825517, FAX: 81 292 826122
Sept. 27-29 Atlanta, GA	ACS/IREC Division	(O) Emerging Technologies in Hazardous Waste Management V	
Sept. 28-Oct. 1 Barcelona, Spain	ECPR	(O) International Conference on Environmental Pollution	ICEP Conference Office, ICIR Secretariat, 11-12 Pall Mall, London SW1Y 5LU, UK, TEL: 4471 930 6825, FAX: 4417 976 1567
Oct. 3-6 Toronto, Canada	CNA/CNS	(O) International Nuclear Congress and Exhibition	
Oct. 24-28 Agusta, GA	U.S. DOE	(O) ER '93	
Nov. 1-5 Williamsburg, VA	ASTN	(O) 3rd International Symposium on Stabilization/Solidification of Hazardous, Radioactive & Mixed Wastes	
Nov. 14-19 San Francisco, CA	ANS	(O) Winter Meeting of the ANS	Meetings Department, American Nuclear Society, 555 N. Kensington Ave., LaGrange Park, IL 60525, TEL: 708-352-6611, FAX: 708-352-6464
December 12-17 Charleston, SC	IAEA	(O) 4th International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere

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