United States Nuclear Regulatory Commission
Office of Public Affairs
Washington, DC 20555
Phone 301-415-8200   Fax 301-415-2234
Internet:opa@nrc.gov

No. S-97-04

NOTE: The graphics included in this speech may be obtained from the NRC's Office of Public Affairs. The speech with the graphics is available on the NRC's web site: <http://www.nrc.gov/OPA/gmo/nrarcv/s-97-04.htm>.

JOINT AMERICAN-RUSSIAN RADIATION HEALTH EFFECTS RESEARCH

Commissioner Greta Joy Dicus
U.S. Nuclear Regulatory Commission

Presentation to the joint meeting of
American Nuclear Society, Washington, D.C. Section and
Health Physics Society, Baltimore-Washington Chapter

January 16, 1997

INTRODUCTION

Thank you for inviting me to address the joint meeting of the Baltimore-Washington area chapters of the American Nuclear Society and the Health Physics Society. My subject is the unique opportunity to learn about radiation health effects from studies of Russian workers and populations in the southern Urals area of Russia who were exposed to radiation as a result of the operation of a Russian nuclear complex located in the southern Urals region.

This opportunity was brought to the attention of the U.S. government in 1992 when then NRC Commissioner Gail de Planque wrote to the Department of State, stating

"The political changes that have occurred in the former Soviet Union have opened up a unique opportunity to study and greatly increase our understanding of...health effects of radiation."

As a result of Commissioner de Planque's initiative, the Russian Federation and the United States governments entered into an agreement to conduct joint research of radiation health effects. Russian and American scientists and physicians are studying radiation health effects in both U.S. and

Russian populations with a focus on those in the southern Urals. Tonight I will describe examples of the types of radiation exposures and data that are the subject of the research as well as the potential benefits that could result from the research and provide a brief history of how this joint research effort came into being. Lastly, I will report on the future of this research effort. When I have finished, I believe that you will agree that the radiation health effects data from the southern Urals may be as significant as the Japanese atomic bomb survivor data and that this research effort deserves your support.

THE MAYAK NUCLEAR COMPLEX IN THE SOUTHERN URALS

The Ural Mountains form the western edge of Siberia and divide Europe from Asia. In the southern part of this region east of the Ural Mountains are the cities of Yekaterinburg with a population of 1.4 million and, 125 miles south, Chelyabinsk with a population of 1.1 million (figure 1). The southern Urals region is about 1,000 miles east of Moscow.

[Figure 1. Map of eastern Europe and Russia showing location of Chelyabinsk and Yekaterinburg]

Shortly after the end of World War II, the Soviet Union began construction of a nuclear weapons production complex ("Mayak") in the region and established nearby a secret, closed city to house the workers. Because of the secrecy, the city was originally known by its postal destination, Chelyabinsk-40 (later Chelyabinsk-65). No longer a secret city, it is now called Ozyorsk by its 90,000 occupants (figure 2). It remains, however, a closed city and entry is through guarded, double gates. Through this area flows the Techa River whose waters eventually discharge into the Arctic Sea through the Ob River.

[Figure 2. Map showing location of Ozyorsk in relation to Chelyabinsk and Yekaterinburg]

The major purpose of the Mayak complex was plutonium production for nuclear weapons. The complex included nuclear reactors, radiochemical and plutonium plants and associated nuclear waste facilities (figure 3). In the earliest years of operation, 1948-1952, Mayak released massive quantities of radioactive materials to the atmosphere and to the Techa River, essentially with little or no controls resulting in contamination of the environment. Additional environmental contamination resulted from a chemical explosion in a radioactive waste storage tank and wind dispersion of silt from the shoreline of a lake used to hold liquid radioactive waste.

[Figure 3. Diagram of Mayak complex]

As a result of the Mayak plant operations and accidents, plant workers and the surrounding populations in the southern Urals region were exposed to high levels of radiation and radioactive materials. In some cases, villages in the most highly exposed areas were evacuated and the populations were relocated to other, less contaminated areas. The following are examples of data on the contamination and radiation exposures of populations and workers. It should be emphasized that the data are preliminary. They were derived mainly from reports of Russian scientists (1,2,3). For purposes of comparison and simplicity, radiation levels will be given in the units used today for radiation dose, rem.

At the beginning of operations of the Mayak plant in 1948, the occupational dose limit was set at 0.1 rem per day and in 1953 was reduced to 0.05 rem per day. However, many Mayak workers were routinely exposed to radiation in excess of the dose limits especially in the early years of operation. In the U.S an occupational dose limit of 0.1 rem per day (36 rem per year) that was originally recommended by a predecessor of the National Council on Radiation Protection and Measurements (NCRP) was used in the Manhattan Project (4). In 1949, NCRP reduced this to 0.3 rem per week (15 rem per year) and later to 5 rem per year, the current NRC limit. The basic NRC limit for the members of the public is 0.1 rem per year. NRC licensees are required to keep all radiation doses "as low as reasonably achievable" (ALARA).

ENVIRONMENTAL CONTAMINATION AND POPULATION EXPOSURES

From 1949-1956, about 3 million Curies (3 MCi) of liquid wastes were discharged by Mayak into the Techa River. In 1951, the radiation level at the discharge site was 180 rem per hour and levels up to 5.4 rem per hour were reported downstream. As a result of the discharges, approximately 124,000 persons were exposed to radiation and radioactive materials. About 7,500 were relocated in the years 1953 to 1961.

Beginning in the late 1970s there were unconfirmed reports of an event in the Urals that resulted in widespread contamination of the environs (5). We now know that this was a chemical explosion in a high level waste storage tank in 1957. This chemical explosion resulted in 20 MCi of radioactive material thrown out from the tank and 2 MCi were dispersed downwind as a plume. This plume contaminated about 23,000 square kilometers and became known as the "Eastern Urals Radioactive Trace (EURT)" (figure 4). About 270,000 persons were exposed and 8,000 were relocated within periods ranging from 10 to 670 days after the explosion.

[Figure 4. Eastern Urals Radioactive Trace (EURT)]

The diversion of liquid waste from Mayak, previously discharged to the Techa River to Lake Karachay, resulted in the accumulation of 120 MCi of radioactive material in this open storage body of water. In 1967, after a drought caused the water level to drop and expose the contaminated shoreline, windstorms dispersed 600,000 Ci into the surrounding environs contaminating 2,700 square kilometers.

Additional radioactive materials in the vicinity of Mayak include buried waste, wastes that were discharged into other bodies of water or are in storage. The total could be as much as a billion curies (Table 1).

[Table 1. Radioactive Materials in the Vicinity of Mayak]

Russian scientists and physicians have established registries of persons in exposed populations. About 90,000 persons are included in the Ural population registry. The Techa River registry includes approximately 26,500 persons who received bone marrow doses ranging from 2 to 400 rem. Additionally, there is a registry of about 17,000 persons who are off-spring of this population. The EURT population includes some 20,500 persons with red bone marrow doses from 1.5 to 90 rem. There are additional registries for about 3,500 persons exposed in-utero and up to 32,000 off-spring of the EURT registrants. The foregoing are examples of registries and are not an inclusive list of available registries. Some persons may be included in more than one registry because of exposures to multiple sources. The registries include personal identification data and medical information. In some cases bioassay information is also available. In other cases, doses will need to be reconstructed. Because of the restrictions on the movements of persons in the former Soviet Union, the whereabouts of the exposed persons when they were exposed can be established with some certainty, an advantage for reconstructing doses from environmental sources.

Additionally, there are registries of Mayak workers.

MAYAK WORKER EXPOSURES

The periods of greatest exposure of Mayak workers occurred in the first decade of operation, 1948-1958. The Mayak worker registry for this period covers 8,800 workers. The mean accumulated doses (MAD) from external radiation for male workers were 102 rem for reactor workers, 173 rem for radiochemical chemical plant workers and 70 rem at the plutonium production plant (Table 2). A unique feature of the Mayak worker population is that female workers comprised a significant fraction, about one-third, of the 1948-1958 worker registry. Female workers received MADs of 40 rem at the reactors, 165 at the chemical plant and 77 at the plutonium production plant.

[Table 2. Mayak Workers (1948-1958)]

The high external doses received over a protracted period of time resulted in the manifestation of clinically observable effects which the Russian physicians, A.K. Guskova and G.D. Baysogolov, defined as chronic radiation sickness (CRS) (6). According to them, CRS is characterized by varying degrees of cardiovascular, gastrointestinal and neural system disorders (Table 3). Of the 8,800 Mayak workers in the 1948-1958 registry, 1,813 (21%) were diagnosed with CRS. (The registry also includes 59 workers who received acute radiation doses of a magnitude sufficient to result in Acute Radiation Syndrome). CRS occurred mainly in workers with accumulated doses in excess of 100 rem including 208 workers with accumulated doses exceeding 500 rem (Table 4). However, CRS was also reported in 222 workers with accumulated doses of less than 100 rem.

[Table 3. Chronic Radiation Sickness]

[Table 4. Mayak Workers (1948-1958) CRS]

Some Mayak workers had significant uptakes of plutonium (Table 5). A registry of 2,283 workers shows a lung MAD of 802 rem for male workers and 1,429 rem for female workers. In this group, 120 cases were reported of plutonium pneumosclerosis, a clinical finding that has been described by Dr. Okladnikova et al. (Table 6) (7). In the west, this has been seen only in experimental animals although a similar effect, radiation pneumonitis, has been recognized in humans a result of high exposure of lung tissues from external sources of radiation, for example, in radiation therapy.

[Table 5. Mayak Workers (1948-1958)]

[Table 6. Plutonium Pneumosclerosis]

As in the case of the population registries, the worker registries include personal and medical data. From the beginning, Mayak workers were provided with personal monitoring devices. These included ionization type devices for recording daily doses and film badges (later replaced by TLD). Early film devices lacked filters to differentiate the type and energy of the radiation but Russian scientists are reconstructing the early dosimetry systems and exposure environs to validate the data. Bioassay data are also available including results from urinalysis samples, whole body and lung counts and autopsies.

THE RESEARCH OPPORTUNITY

What we know about human radiation health effects is derived mainly from the Japanese atomic bomb survivors and persons exposed to radiation for medical purposes. The main characteristics of these exposures are that they were high dose and/or dose rate. However, this is not characteristic of the lower dose, low dose rate exposures of the public and radiation workers as the result of normal nuclear operations. To estimate what the radiation health effects are in these ranges from the Japanese atomic bomb survivor data requires extrapolation from that data. The particularly unique feature of the southern Urals populations is that their exposures occurred at low dose rates over long periods of time over a wide range of doses. The doses resulted from external radiation and from ingested radioactive material. Thus, the southern Urals data has the potential to significantly expand our knowledge of radiation health effects. The results of the research could reduce the uncertainties in risk estimates and modify the assumptions that are made when developing standards for radiation protection.

AMERICAN-RUSSIAN INITIATIVES

Commissioner de Planque's 1992 letter initiated a series of U.S.-Russian Federation discussions that culminated in an agreement signed by Secretary of State Christopher and Foreign Minister Kozyrev at the 1994 Moscow summit. That agreement created a framework for joint American-Russian research. A Joint Coordinating Committee for Radiation Effects Research (JCCRER) composed of U.S. and Russian government representatives implements the agreement. Day-to-day activities are carried out by an Executive Committee. The JCCRER membership includes co-chairs from the U.S. Department of Energy and the Ministry of the Russian Federation for Civil Defense Affairs, Emergencies and the Consequences of Natural Disasters (EMERCOM) and representatives from the U.S. NRC and Departments of Health, Education and Human Resources, and of Defense, and, the Russian Federation Ministries of Health and of Atomic Energy (MINATOM) (Table 6).

The JCCRER initially met in Washington, DC, in October, 1994 and approved a series of feasibility studies for studying radiation health effects in populations (Direction 1) and in workers (Direction 2) and to determine information needed for decision making in responses to accidents (Direction 3). In October, 1996, the JCCRER reconvened in Moscow, Russia.

The Moscow meeting was preceded by a visit by U.S. representatives to the southern Urals who met with scientists at Branch 1 of the Biophysics Institute in Ozyorsk and the Urals Research Center for Radiation Medicine in Chelyabinsk. The delegation was headed by U.S. JCCRER Co-chair and DOE Assistant Secretary Dr. Tara O'Toole and included JCCRER members Dr. Anna Johnson-Winegar from the Department of Defense, Dr. Richard Jackson from the Center for Communicable Diseases and me. We also visited the Mayak plant and the hospitals in Ozyorsk and in the villages of Kasli and Tyubuk and laboratories at Branch 1 and at the Center.

The visits served to confirm the potential opportunities for research and to identify areas for priority attention. A clear need exists to preserve the data which, in many cases, exists only in the form of single copies of paper and thus are vulnerable to destructive hazards such as fire. Russian scientists and physicians recognize the potential value of the data and are strongly committed to the tasks ahead of them despite constraints imposed by limited funding resources. When the U.S. delegation arrived in Moscow for the JCCRER meeting, we had been energized by what we had seen and heard in the southern Urals.

THE CHALLENGE FACING THE JCCRER

The Moscow meeting of the JCCRER resulted in agreement on paths forward. Most of the feasibility studies have been completed and the results indicated that full scale research should proceed in Direction 1 and 2 (effects on populations and workers). Plans for Direction 3 await further study. Unfortunately, because of U.S. Federal cutbacks of DOE's budget, which is the main U.S. funding source, the JCCRER is faced with a $ 1 million shortfall for FY 97. (The shortfall does not include a portion of the worker study which the NRC plans to fund pending satisfactory completion of the feasibility study and submission of an acceptable research proposal). Further, DOE funding for the outyears beyond 1997 is uncertain. To accommodate the shortfall in FY 97, adjustments in research priorities and schedules were made. Additionally, priority was given to data preservation efforts.

About $20 million is needed over the next 5 years to complete the initial JCCRER research efforts. Although the significance of the southern Urals data is well recognized within the scientific communities, public awareness and understanding of its importance is needed to build support for a political willingness to fund the work to completion. This is an especially formidable task in these days of shrinking resources but it must be met. The opportunity and the potential benefits are too great to let pass. Your help in building this support is needed and would be welcome.

REFERENCES

1. See Health Physics v. 71, no. 1 (July 1996). This issue contains a set of reports presented by scientists from Russia, Ukraine and Belarus at the 1994 Annual Meeting of the Health Physics Society in San Francisco, CA. The papers on the consequences of operation of the Mayak facilities are found

on pp. 61 to 93.

2. Roessler, G., "NRC Commissioner Greta Dicus is Part of U.S. Delegation to Russia," The Health Physics Society's Newsletter v. XXV, no. 1 (January 1997).

3. Kellogg, S.L. and Kirk, E.J., editors, "Assessing Health and Environmental Risks from Long-Term Radiation Contamination in Chelyabinsk, Russia," Proceedings from the 1996 AAAS Annual meeting Symposium, 12 February 1996, Baltimore, MD, American Association for the Advancement of Science, Washington DC (1997).

4. Kathren, R.L., "Historical Development of Radiation Measurement and Protection," CRC Handbook of Radiation Measurement and Protection, CRC Press, Inc., West Palm Beach, FL (1979).

5. Medvedev, Z., Nuclear Disaster in the Urals, Vintage Books, New York, NY (1980).

6. Guskova, A. & Baysogolov, G., Radiation Sickness in Man, Izdatel'stvo "Meditsina" (1971), English Translation, U.S. Atomic Energy Commission, TID-4500, Washington, DC (1973).

7. Okladnikova, N., et al. "Occupational diseases from radiation exposure at the first nuclear plant in the USSR," Sci. Tot. Environ. v. 142, pp. 9-17 (1994).