RISK AND SAFETY

INDUSTRIAL NORTH

NUCLEAR TECHNOLOGIES AND ENVIRONMENT

Risk and Safety

Industrial North

Nuclear Technologies and Environment

Moscow
2004

The Industrial North. Nuclear Technologies and Environment.
— Moscow, «Komtechprint» Publishing House, 2004, 40 p.
ISBN 5-89107-053-7

The edition addresses specialists of the legislative /executive authorities and those of local government of the north-west region; activists of public environmental movements; and teachers and students of higher education institutes as well as all those who are interested in the problems of stable development of the Russian North.

This document is prepared by the Nuclear Safety Institute (IBRAE RAS) under work sponsored by the United States Department of Energy.

ISBN 5-89107-053-7

INTRODUCTION

Industrialization of the majority of Russian regions took place during an era when environmental safety was not given proper attention. The country's defense issues and purely economic objectives were prioritized.

Forced development of the Kola Peninsula's natural resources began in the 1930s, and the Soviet nuclear submarine group, the biggest in the world, was created at the beginning of the 1960s. The developments defined ecological problems for the Murmansk/Arkhangelsk regions. Today, the public is deeply concerned about safety of base sites and service points for nuclear submarines (**NS**) and vessels of the North fleet; effects of nuclear weapons tests on the Novaya Zemlya; including peaceful nuclear explosions; and safety of the Kola Nuclear Power Plant (**NPP**).

To what extent are these fears justified from the scientific point of view? It is possible to get an answer to the question, when analysing objectively the three following interrelated issues:

1. *Where among technogenic risks do radiation risks rank?*
2. *Are severe radiation accidents possible in the region?*
3. *Are the respective organizations and local authorities ready for effective actions to protect the population in case of radiation accidents?*

In the «post Chernobyl» community, potential health risks began to be associated mainly with radiation. Apart from that, many other risk factors were considered as minor or were not taken into account. Thus, the first question is a key to comprehension of an actual environmental situation in the region. The authors of this brochure answer the question, having studied plenty of the material, including the data of the state surveillance and environmental services of the Murmansk/Arkhangelsk regions.

Theoretically, the probability of sizable radiation accidents may not be excluded. Therefore, a considerable part of the brochure is dedicated to the forecast, prevention and mitigation of nuclear/radiological emergencies. It is of importance that the population is aware of whom is responsible for public protection; what public information channels and types of emergency protective actions can be; as well as to what extent these or those exposure doses are dangerous.

The brochure from the Risk and Safety Library is compiled on the initiative of the US Department of Energy (DOE) and EMERCOM of Russia within the scope of activity of the Arctic Council Emergency Prevention, Preparedness and Response (EPPR) working group. The editorial board of the Risk and Safety Library: academician A. Sarkisov, RAS corresponding member L. Bolshov, professor R. Arutyunyan, and Dr. I. Linge. The brochure is prepared in the Nuclear Safety Institute (IBRAE) of Russian Academy of Sciences by the team of authors: Dr. E. Melikhova (leader), Dr. I. Abalkina, L. Vorobyeva, Dr. I. Zaitsev, Dr. S. Kazakov, M. Ivanov, N. Ugarova, professor V. Logachev (the State Institute of Biophysics) and G. Dernovoy (the Institute of High Energy Physics). I. Veselov and T. Marchenko, representatives of EMERCOM of Russia's top management, were actively involved in the discussion of the brochure's concept and content.

English translation of the brochure is made by A. Troitskaya (IBRAE), edited by Regina Galer from US DOE side and E. Melikova from IBRAE side. Design by M. Ivanov and A. Pavlov (IBRAE).

The brochure addresses specialists of the legislative/executive authorities and those of Murmansk/Arkhangelsk regional government; activists of public environmental movements; and teachers and students of higher education institutes, as well as the general public interested in the issues of stable development of the Russian North.

Ecological Portrait of the Region

The neighboring Murmansk and Arkhangelsk regions have many features in common: big seaports and Navy bases; the shipbuilding industry and scale extraction/processing of natural resources. However, compared with the Arkhangelsk region, the industrial history of the Murmansk region is much shorter.

Industrial development of the Kola Peninsula started in the first decades of the 20th century. First, a railroad and a seaport were built, followed by intensive extraction of natural resources. More than 60 sizable deposits of various minerals were found in the peninsula's interior, including the unique deposit of apatite ore containing phosphorus, titanium, iron and aluminium. Ores of copper, nickel, zirconium and other rare materials are being extracted. There are great reserves of mica, clays and stuff for building materials, and semiprecious and ornamental stones. As of today, the Murmansk region provides for 100% of Russian production of apatite and 12% of iron ore concentrates, 14% of refined copper and 43% of nickel. The share of metal mining industry and non-ferrous metallurgy makes up 40%.

In extreme polar climate, the Murmansk region's industry developed through creating the city-forming industries. More than 90% of the inhabitants live in cities, and more than a half of the industrial production is concentrated in Murmansk, Monchegorsk, Kirovsk, Apatity and Kovdor. In a number of cases, due to the «centers» of high production, the vulnerability of the northern landscape and its weak selfcleaning ability, the local ecosystems' irreversible degradation took place. Approximately 1% of the regional territory is fully affected by anthropogenic impacts and up to 3–8% of the land is in the areas of gas/oil and other resource extraction.

The history of industrial development of the Arkhangelsk region includes centuries. For centuries, Arkhangelsk was a vitally important seaport, the centre of shipbuilding and trade in Russia. Lacking sizable deposits of minerals, the region's basic industries are timber and pulp and paper (45%). The region provides more than 10% of Russian production of merchantable wood/lumber, and about one third of market pulp, paper and paperboard. The Arkhangelsk region's share of the Russian export lumber makes up 20%; and that of pulp and paper production — 30%. Engineering and metalworking is another important industrial activity in the region. Industrial oil/gas production in the Nenetsky autonomous region, and bauxite extraction in the Plesetsky district, is under way.

The period of 1970–1980 was characterized by the most intensive environmental impacts both in the Murmansk and in the Arkhangelsk regions. Abrupt reduction in production volumes occurred in the 1990s, as all over Russia. For the past 5 years, active growth in natural resources extraction has replaced the economic recession. It is only natural that the industrial development of both regions, considering their varied histories, has involved serious ecological problems associated with air and surface water contamination. For instance, the average annual concentration of benzapilene, a dangerous carcinogenic, reached nearly three times the federally established maximum permissible concentration (**MPC**) in Arkhangelsk in 2002.

The strategic location of the Murmansk/Arkhangelsk regions due to their outlet to the north seas predetermined the deployment on their coast of base sites for NS of the North fleet and specialized shipbuilding plants and dockyards. Starting from 1955, nearly 250 NS and 5 surface ships, two-thirds of which are assigned to the North fleet, were built in the former USSR. The ships of the nuclear icebreaking fleet also are based in Murmansk.

Regarding environmental impacts, people often speak of radiation risks associated with the use of nuclear technologies. In fact, radioactive contamination has occurred in some NS base sites. Many NSs need decommissioning, and sizable accidents at NPPs and nuclear power installations could involve heavy effects. The fact is, however, that even in the sites of local radioactive contamination, one does not observe such ecosystem damage as in the district of Monchegorsk and in many other industrial centers.

Is the risk of using nuclear power in the region justified? Apparently, yes, and the authorities of the Arkhangelsk/Murmansk regions understand it well.

The strategy of economic development worked out by the administration of the Murmansk region aims at increasing the population's quality of life and at improving environmental health. Increased competitiveness in the ore-mining industrial complex, while preserving total extraction volume; initial development of the Shtockman gaseous condensate deposit in the Barents Sea; and nuclear power development, including the construction of a new line of the Kola NPP, are among the key objectives. Reconstruction of the Joint Stock Company «Pechenganickel» metallurgical production to reduce sulphur dioxide releases and to recycle industrial waste is planned to improve environmental health. A considerable volume of activities has to be performed with respect to nuclear submarine recycling and remediation of affected lands.

Expanded natural resource extraction and increased processing efficiency are priorities for the near future in the Arkhangelsk region. For instance, preparation for the industrial development of diamonds at the Lomonosov deposit, the third-largest reserve on earth, is in process. A floating NPP, the first in the world, will be constructed in Severodvinsk to make for solving the issue of power supply in a major locality. Apart from that, expenses for organic fuel delivery

As a result of aerial sulfur dioxide releases by the «Severonickel» metallurgical industrial complex near Monchegorsk, a waste area formed, where no moss or lichen are present within 50 km in the direction of the prevailing wind. The releases bypass the city for most of the year due to local wind patterns.

Compared with the year 1990, the industrial complex has reduced by five times its sulfur dioxide releases. However, it will take tens or, perhaps hundreds, of years to recover the environment.

and tariff compensation will be abruptly cut down. A considerable volume of activities on NS recycling has to be performed at the facilities in the Arkhangelsk region. After the NS recycling programs are finalized, base sites of the peaceful/military nuclear fleet will be preserved. The decision on additional use of nuclear technologies is based on scientifically justified estimates of radiation risks for the public and environment. However, projects dealing with nuclear technologies often come across desperate opposition from the local population. The reason for public disagreement can be explained by distinctions in risk comprehension and perception.

Varied Risk Perception

Various actions to prevent radiation accidents are implemented at nuclear and radiation hazard facilities. They are aimed at increasing operational safety and, ultimately, at risk reduction for the public and environent.

For example, let us consider the site storage project at the «Atomflot» repair facility, aimed for spent nuclear fuel (SNF) from NSs decommissioned. The site storage is essential to speed up the NS decommissioning. With implementation of state-of-the-art storage technologies and new transport packing containers, safety will increase for SNF temporary location (See more detailed information on p.19).

However, the city administration and the inhabitants of Murmansk have desperately opposed the project. Not knowing the details of the technology, people cannot fairly evaluate the actual project advantages. Apart from that, people perceive the word combination «SNF storage» as hazardous waste storing near their homes. Any plans to locate potentially hazardous facilities and entities of national level arouse, as a rule, increased protest activity from local public. The reactions are world-known as the NIMBY syndrome («not in my backyard»).

Open public dialogue on more fair distribution of risks and advantages from a new facility pave the only way to achieve consensus.

Environment and Health

How great of a hazard is environmental contamination to human life and health? First, health depends on environmental conditions and lifestyle. According to WHO specialists' estimates, this factor contributes more than 50%, heredity contributes 15–20%, and medicine contributes 10%. The rest, 15–20%, depends on environmental quality, i.e. on sanitary conditions and ecological health. This is an average estimate; in exceptional cases, the environment's contribution may run 40%.

It is proved that inhalation of polluted air, among other factors, leads to illnesses of the circulatory system, respiratory diseases, and neoplasm growth. In Western European nations such as Austria, France and Switzerland, where the average concentrations of atmospheric particulates are 5–10 times below the permissible concentration limit (PCL) established in Russia, air pollution causes 40,000 deaths per year, about 6% of all cases, («The Lancet», Vol. 352, 2000, pp. 795–801).

In Russia, 4–20% of all deaths are attributed to atmospheric air pollution. The main hazard lies in non-carcinogenic impacts of dust particles. The risk is estimated from 10^{-4}–10^{-3} (from 1 to 10 deaths per 10,000 people annually). As a rule, the carcinogenic risk from chemical air pollutants is less (10^{-6}–10^{-4}). The radiation risk is approximately the same level in the Chernobyl zone settlement, where cesium contamination in the soil exceeds 15 Cu/km^2 and radiation doses range from 1 to 10 mSv/year, exceeding the permissible dose limit by ten times.

mSv (millisievert) is a dose unit for a person at radiation exposure.

For residents of the Northwest region, the background exposure from all radiation sources makes up 2.9 mSv/year, including that of 0.1 mSv/year from technogenic sources (consequences of accidents and nuclear weapon tests, the NPP activity, etc.). The Russian Federation law specifies the permissible extra dose limit for exposure from technogenic sources as 1 mSv/year.

Risk estimation is a probability for occurrence of adverse effects at the impact of a certain factor on the individual. If experts know the statistics of a sickness/death rate caused by that factor, they take an a posteriori frequency of sickness or death in a group numbering to at least 1000 people as the risk estimation. If they lack such data, risks are estimated on the base of certain assumptions. For example, in case of a chemical risk, chemicals causing cancer among laboratory animals are assumed to be carcinogens for the individual. The linear model is used to evaluate the impact of low radiation doses (See page 9).

The risk in this brochure is considered to be a probability of death from this or that impact. The risk of death from natural/technogenic factors may change widely: from a few people per a million of residents (10^{-9}) to several tens of them per 1000 people/year (10^{-2}). The risk of 10^{-9} corresponds to the probability of death during a tornado or a flood. Representatives of especially dangerous professions, for instance, firemen, are subject to the risk of 10^{-2}.

Priorities in Risk Reduction

Scientific methods of risk estimation used in the radiation safety field since the 1970s have been integrated into environmental protection since the late 1990s. On the strength of this, approaches to regulation, methods to define permissible releases and wastes, opportunities to monitor and even the attitude to observe procedures, appear stricter in assessing radiation risk than they do with regard to chemical risk.

As compared with measurements by chemical substances, accuracy of measurements in the current radiation monitoring system is several orders higher. The system registers changes in the environment at levels that are a million times lower than the permissible dose limit (**PCL*** radiation equivalent). It is possible in a number of cases to define air and water-borne concentrations of chemical pollutants only if the amount exceeds PCL. Uncontrolled pollutants represent a major hazard for the public: their contribution to the total air pollution risk for human health is estimated as 70%.

As a result, a serious imbalance has occurred in the methods of handling radiation and chemical risks.

For example, the PCL-associated risks of chemical carcinogens are tens or hundreds of times higher than the radiation risks at the level of permissible dose limit. Thus, the lifelong carcinogenic risk from hexavalent chromium, at the PCL level, is estimated as $2 \cdot 10^{-1}$ (2 cases of death per every 10 people). The radiation risk at chronic exposure at the level of permissible limit is no more than $5 \cdot 10^{-5}$ (5 cases per hundreds of thousands of people).

In the Chernobyl zone, the level of risk is 10^{-4} at the exposure dose of 5 mSv/year and the state pays to rehabilitate the area and protect the population.

Expenditures include pecuniary compensation for potential health damage. But state investments in the decrease of risk for more than 20 million residents of industrial cities of Russia that inhale the heavily polluted air are not yet envisaged.

Which risk necessitates more immediate remediation? With sufficient resources, it is necessary to mitigate all risks to an acceptable level. However, considering the chronic lack of means for the most urgent needs, it is important to spend the available funds to eliminate the most serious risks.

** PCL = Permissible Concentration Limits*

Radiation and Chemical Risks

The uncertainty affecting the risk estimation results at 100 or more times is typical of harmful chemical substances with unknown properties. Because the radiation impact on humans has been under review for more than 100 years, there is considerably less uncertainty in such estimations. At low doses, exceeding the dose limits by times, no reliable medical effects of human exposure have been revealed yet. The conservative method dictates that all estimates are given with double «safety margins», as minimum considerations for radiation safety.

Therefore, the linear hypothesis is used to estimate risks in the area of low doses. The model assumes that even the lowest doses may cause long-term effects. Estimates of so called population risks are performed through it. Valuable estimates of radiation risks are obtained through summing of large number of individuals with low doses.

We will also apply the above procedure, in spite of the fact that the International Commission on Radiological Protection is developing new recommendations which directly indicate that such approach brings to sufficient overestimation of radiation risk forecast.

In compliance with Russian Radiation Safety Standards (**RSS-99**), the level of negligibly low (acceptable) radiation risk makes up $1 \cdot 10^{-6}$ (one extra death per a million of people in 70 years). In the field of chemical pollution, the level of acceptable risk is not legislatively determined (in a number of countries it also is established at the 10^{-6} level) and the decisions about environmental quality management are supported by hygienic standards (PCL).

Contamination level in terms of PCL	Chemical mixtur	Radioactive substances
100	Isolated instances	Have not been recently observed
10	Are being often observed	
1	Susceptibility threshold for a major part of measurements	
$10^{-1}...10^{-8}$	Are not fixed and discussed in the majority of cases	Are fixed and discussed

Industrial Centers

Let us consider two factors of ecological risk: chemical pollution in the air and potential radiation hazards from nuclear facilities.

Overall, the harmful air pollution in the Murmansk/Arkhangelsk regions does not exceed federal sanitary standards. Due to cyclonic activity with moderate and strong winds, chemical substances quickly disperse in the air. However in the cities, the situation is different. Non-ferrous processing/emitting facilities mainly contribute to the air pollution, the industrial complexes «Pechenganickel» and «Severonickel» and the «Kandalaksha Aluminium Plant» being the basic sources. The highest chemical risks are in the Murmansk/Arkhangelsk regional centers, and in immediate proximity to metallurgical facilities.

The Kola NPP, vessels and coastal bases of nuclear fleets relate to potentially-hazard sites. Radiation monitoring runs in all environments in nearby potentially hazardous nuclear sites related to the Kola NPP and landmarks of nuclear fleets. Monitors measure in the open reservoirs; in soil and vegetation; in bottom sediments and surface air; in the air fallouts and snow cover; and in existing fish and foodstuffs. The monitoring results of the 30-year observation certify that the nuclear sites' impact on the radio-ecological situation formed previously is, overall, insignificant.

Global releases from previous nuclear weapons tests, including those ones performed in the Novaya Zemlya test area, strongly impact the radiation situation. Radioactive waste disposal in the Barents and Kara Seas did not actually impact the level of radioactivity in the seawater. We immediately point out that large cities do not differ from other territories of the region by basic radiation parameters (a dose rate and dose-forming nuclide content) and they cannot be referred to as zones of high radiation risk.

Suspended Particulates in the Air

Harmful effects: illnesses of cardiovascular system, diseases of respiratory system and lungs neoplasms.

At the dust particle concentration of two times the PCL, the individual annual risk of death is 10^{-3}*. Inhaled particles directly affect respiratory paths and other organs, due to toxic impact. People with chronic lungs abnormalities, cardiovascular diseases, asthma or frequent chest colds as well as the elderly and children, are especially sensitive to fine, suspended particles.*

Low cost methods to mitigate risk: Plant trees and gardens in yards, along streets, and throughout cities; clean with damp towels indoors, etc.; wet and clean municipal roads.

Murmansk

Particulate air pollution is the basic health risk factor for 337,000 inhabitants of the city. Data of the State Sanitary Epidemiological Surveillance regional centre shows about 220 extra deaths per year. This corresponds to individual annual risks of $6{\cdot}10^{-4}$, or life risks of $4{\cdot}10^{-2}$. (Hereinafter, the individual annual death risks are given).

Carcinogenic risks from harmful chemical mixtures in the air are 2 orders of magnitude less. According to Roshydromet's monitoring data, the carcinogenic risk of nickel compounds is at the level of 10^{-5} in Murmansk.

Monchegorsk

The particulate air pollution, the individual risk being about $3 \cdot 10^{-4}$, i.e. nearly 20 extra deaths per year, represents the main health risk for 57,000 inhabitants of Monchegorsk. The «Severonickel» industrial complex functioning near the city annually releases hundreds of tons of metallic nickel into the atmosphere. The estimated individual carcinogenic risk is $4 \cdot 10^{-7}$.

Availability of a waste area in immediate proximity to the city makes one consider these assessments minimal.

Kandalaksha

Kandalaksha, where about 45,000 people live, has the highest mortality rate in the Murmansk region. Research at the North-West Hygiene/Public Health Research Centre on risk evaluation for the development of «ecologically» incurred deaths has shown that the Kandalaksha aluminum plant is the basic source of atmospheric pollution. Out of all harmful substances, the dust particle releases, the individual particle size not exceeding 10μ, mostly contribute to mortality. The individual risk of their impact makes up $8 \cdot 10^{-3}$, i.e. about 370 death cases per year. This value is much higher than that in Murmansk or Monchegorsk.

We should note that the previous work to estimate the risk of suspended particles in Kandalaksha gave results of 10 times less. This may exemplify the fact that more comprehensive research drives a considerable increase in chemical risk assessments.

According to the Roshydromet's monitoring data, the individual carcinogenic risk of nickel compounds makes up $2 \cdot 10^{-6}$ in the city.

Arkhangelsk

355,000 inhabitants of Arkhangelsk live with a very high level of air pollution. Adverse air conditions brought about by the releases from woodworking and pulp and paper facilities located in the city as well as from the Arkhangelsk coal-fired thermal power plant.

The particulate air pollution causes approximately 114 extra death cases per year, mainly from diseases of the respiratory and cardiovascular systems. The individual annual risk makes up $3 \cdot 10^{-4}$.

Benzapilene relates to high-hazard substances (the second class of a hazard) and is a carcinogen for the individual.

Nickel is also a carcinogen for the individual.

Carbon Disulphide has s strong irritant effect on mucous tunic and skin; it impacts the enzymatic systems, vitamin/lipid change and endocrine/reproductive systems.

Hydrogen Sulphide is an irritant and damp gas affecting the eyes, and the upper respiratory system and damaging the deeper-lying structures.

Increased concentrations of Methyl Mercaptan entail growth among the children of the respiratory/otolaryngologic diseases, dermatoses and diseases of the subcutaneous fat, as well as respiratory infections.

Formaldehyde has irritant, allergic, mutagenic and carcinogenic effects. It increases carcinogenesis caused by other agents, in particular by benzapilene.

High concentrations of specific mixtures, such as methyl mercaptan, carbon disulphide, hydrogen sulphide and formaldehyde, which are characteristic of the releases from woodworking and pulp and paper facilities, are registered in the city. The airborne methyl mercaptan concentration is the highest. Its average annual concentrations reached 4–6 times the maximum permissible concentration (MPC) between 1997–2001. Cases of extremely high pollution with concentrations 50–100 times higher than the MPC were observed annually. The situation has recently changed for the better. In 2002, the average annual methyl mercaptan concentration in the air did not exceed the MPC and the maximum single concentration was 17 times the MPC.

There are no reliable risk estimates on methyl mercaptan as yet. The formaldehyde concentrate causes an annual carcinogenic risk of $7{\cdot}10^{-7}$.

Novodvinsk

This is a single-industry city where 49,000 people live. The Arkhangelsk pulp and paper industrial complex produces nearly 100% of all industrial production in the city. It is also the main source for airborne methyl mercaptan, hydrogen sulfide, and carbon disulphide, specific substances.

Single methyl mercaptan concentrations exceeding 400–650 times the MPC were observed between 1997–2001. The average annual concentrations made up 6–12 times the MPC. As in Arkhangelsk, the situation has recently improved. In 2002, the average annual methyl mercaptan concentration exceeded by 1.8 times the MPC and the maximum single concentration was 42 times the MPC.

The power-generating sites in the city (three thermal power plants), draw 50% of their fuel from coal. These plants are responsible for emitting particulates and formaldehyde. Average annual formaldehyde concentrations in the atmosphere make up 2 times the MPC, causing an individual annual carcinogenic mortality risk equal to 10^{-6}. The suspended substance particulates cause health risks of $3{\cdot}10^{-4}$.

Severodvinsk

Severodvinsk is the centre of nuclear submarine construction. The nuclear complex facilities, such as «Sevmashpredpriatie», «Zviezdochka», «Sever», «Arctica», and «Poliarnaya Zvezda» are located here. However, it is the power utilities, and not the above-mentioned facilities, that contribute most to the atmospheric releases of harmful substances.

The carcinogenic risk from benzapilene/formaldehyde is estimated at $1{\cdot}10^{-6}$.

At the same time, by results of radio-ecological monitoring run by the radiation safety services, excess control levels at the industrial sites have not been fixed for the overall period of observation. For instance, volume radioactivity of the water at the «Zvyozdochka» facility ranges within the intervention level.

The intervention level is the level of radiation factor at the excess of which certain protective actions should be taken.

Poliarnye Zori City (The Kola NPP)

Radiation monitoring within the Kola NPP location has been done since 1972. The situation by the main radiation parameters (the dose rate and radionuclide content) is the same as in surrounding regions.

Cesium/strontium radionuclide concentration in the surface air within the surveillance zone is below the susceptibility threshold of the equipment.

Radioactive cesium/strontium are long-lived fission products. Their half-decay period is nearly 30 years; therefore, these radionuclides define mainly long-term consequences of accidents at NPPs.

The water radioactivity is thousands times lower than the intervention levels established for the drinking water by the radiation safety standards (RSS-99). The results of monitoring over the vegetation soil and other environmental objects show that the radioactivity levels are same at any distance from the NPP. These levels have formed as a result of global releases after the nuclear weapons tests.

Estimated values of extra radiation doses for the population in the surveillance zone do not exceed 0.01 mSv/year (i.e. they are 100 times less than the dose safety margin of 1 mSv/year). The hypothetical, annual risk of the $4 \cdot 10^{-7}$ level is associated with it. To make use of the method mentioned on page 9 to assess the population risk for 17,000 people in Poliarnye Zori city, we will obtain one extra death from cancer for the period of 100 years. Therefore, one can speak of the Kola NPP as a potential source of radiation risk. Extra radiation risk is negligibly low under normal conditions.

Radiation impact on the individual depends on the dose received.

Low doses are considered to be single doses in the range of 5–100 mSv or annual doses of 5–10 mSv. From the medical and hygienic point of view, there are no proofs of harmful health effects of low radiation doses, though mechanisms of the human biological response to low radiation impacts remain the most intriguing field of investigation for radiobiologists.

Neither the doses obtained during the life period, nor single doses below 1000 mSv (moderate doses) cause any acute symptoms. The only possible effect is the cancer risk increase at the later stage of life.

The dose of 1000 mSv and above (a high dose) can be obtained only in exceptional cases, for instance, during the radiotherapy or in emergency at the nuclear site during a severe accident or in case of a nuclear war.

A single dose ranging from 2000 to 3000 mSv inevitably causes a radiation sickness. When getting the doses above 6000 mSv, chances to survive for longer than a few weeks are rather low.

Sites of RW Discharge/Burial in the Arctic Seas

Although the arctic seas remain relatively uncontaminated compared to other seas, according to Russian oceanologists' assessments, some sites of water areas have excess oil products, phenol and heavy metls, above the MPC. Mining and smelting industries; pulp and paper plants; activity of the North fleet and that of the transport and fishing fleets; and crude waste water discharges from cities play the greatest role in marine contamination of the region. Fuel bases and stores are the main sources for oil product discharge into the sea and internal ponds.

At the same time, the environmental public is mostly concerned about possible effects of radioactive waste (**RW**) discharge and burial in the arctic seas. Solid/liquid RW discharge into the seas started with appearance of the first nuclear submarines. More than 12,000 RW containers and 10 reactor installations from emergency nuclear submarines and the «Lenin» ice-breaker sank from 1961–1990.

At planned burials, safety measures were envisaged. Hard RW sank in special metal reservoirs, and the NS reactors were filled with a special mixture that prevents radioactive substances from contact with the water within a few hundred years. Specially assigned regions were selected for discharging liquid RWs (See a diagram on page 29).

To what extent are the effects of RW discharge/burial in the arctic seas dangerous? Five joint Russian-Norwegian sea voyages to study the general state of radioactive contamination were done for the recent decade, including an expedition to the region of the «Kursk» nuclear submarine wreck.

The expeditions' results show that the RW burial has not impacted the general level of radioactivity in the seawater. Regional measurements around burials of spent nuclear fuel reveal local centers of increased radioactivity in bottom sediments of the Abrosimov and Stepovoy Bays (the shore zone of Novozemelsky testing area), located a few meters from the sunken objects. Apart from that, there are small leaks from the sunken RW containers in the Abrosimov Bay, where a twofold-fourfold increase of radiocesium content shows up in bay-bottom sediments. However, the level of radioactivity in the water of the bay does not differ from that of the open sea.

It does not mean that solving the objectives of NS complex recycling and coastal bases remediation can be deferred. The volume of accumulated radioactive waste and spent nuclear fuel (**SNF**) is too great.

In 1994, the oil spill occurred in the Arkhangelsk region, nearby the city of Usinsk. The oil reached the Barents Sea by the Pechora River and the oil spot spread for 18 km.

Increased sickness rate with regard to the digestion system among the adults was observed for two years in the Kolva settlement affected by the accident. Medical supervision over the children showed increased number of diseases of the respiratory system and overall immunity decrease, having entailed the growth of infectious diseases. The oil or its components were revealed in the internal and stomach of domestic animals from several settlements located by the Pechora River in the 150-km distance from the site of accident. The number of fish (the white-fish and the European umber) especially sensitive to water contamination has decreased by 100–1000 times in contaminated rivers and lakes. The fish from the Kolva River basin frequently appears to have morphological deviations (abnormalities). Ten years after the accident, the river is not yet suitable for industrial fishery.

The Novaya Zemlya Testing Area

During the period 1955–1990, nuclear weapons tests were conducted on Novaya Zemlya. In total, 130 tests were carried out. The world's heaviest airborne nuclear explosion (50 Mt) was performed in 1961.

Tests vary by levels of radioactive contamination in the vicinity of the explosion. The highest contamination levels occur in terrestrial and underwater explosions; the next highest levels of contamination occur with unplanned underground explosions and planned airborne explosions. Underground nuclear explosions cause the least amount of contamination, without impacting the radiation status, even in the test area.

Eighty-five airborne nuclear explosions were carried out on Novaya Zemlya. Radioactive contamination of the locality after air tests mainly takes place in the epicenter of the explosion. The explosion products rise jointly with a formed cloud to a great height where they disappear forming global fallouts, as a result of which a small radioactive contamination in the remote zone takes place. Total values of annual doses for the inhabitants of all regions of the Russian Federation after the air tests on Novaya Zemlya did not exceed federal permissible sanitary and hygienic standards.

The northern territories, where indigenous people who raise deer live, present an exception. The peculiarities of radionuclide migration in the Polar Regions are such that radiocesium concentrations in the reindeer's meat were higher than those allowed at that time by sanitary standards. The venison is a basic component of the indigenous peoples' diets, thus the harm from its exclusion from the diet could exceed the benefit from the exposure prevented. Therefore, specialists from a number of countries, including Finland, have concluded that it is expedient to mitigate the sanitary standards.

Apart from the underground and air tests, there were one terrestrial and three underwater tests run on Novaya Zemlya. The test intensities were small, and the radioactive trace actually formed within the prohibited test area, not negatively impacting the populations of neighboring countries.

The current radiation situation in the Murmansk/Arkhangelsk regions does not have any specific peculiarities dealt with the nuclear weapons tests.

The Novaya Zemlya test area has two sites of increased contamination density. These are on the shore of the Chernaya bay, where a terrestrial nuclear explosion was performed, and a site on the shore of the Matochkin Shar belt, where steam and gas containing a radioactive mixture flowed into the gallery during the underground test. One has given these districts a radiation-control area status, and the rest of the test area is considered to be relatively «pure».

More than 400 airborne nuclear explosions were performed in international test areas from 1945 to 1981, a result of which 12.5 tons of fission products were released into the biosphere. Since 1951, global fallouts have increased environmental contamination in the Northern hemisphere. By 1964, the density values reached maximum and began gradually to decrease, mainly due to natural radioactive decay of the explosion products.

The present doses from global fallouts in the Northern hemisphere on average make up about 0.015 μSv/year, this being at least sixty times below the does safety margin (1 mSv/year).

Sites of Peaceful Nuclear Explosions

There were two underground nuclear explosions in 1972 and in 1984, performed to mill ore body at the Kuelpor apatite deposit, 20 km north of Kirovsk, the Murmansk region. Those explosions were accompanied with a release of radioactive products and resulted in environmental contamination by short-lived radionuclides. A few days afterward, when the short-lived radionuclides decayed, the radiation situation in the town of Kirovsk settled to normal. On conservative estimates, human exposure doses accumulated during the period could reach several millisieverts.

Three nuclear explosions were performed in the Arkhangelsk region for deep seismic sondage of the earth's crust and one explosion — for covering the gas blowout in the Nenetsky Autonomous Region. Radioactive products did not actually appeared on the terrene and the on-site radiation levels did not increase.

As of today, all the galleries and boreholes where the industrial explosions took place are suspended; radiation is at natural background level and occasional radiation control is under way.

Comparison of Risks from Different Factors

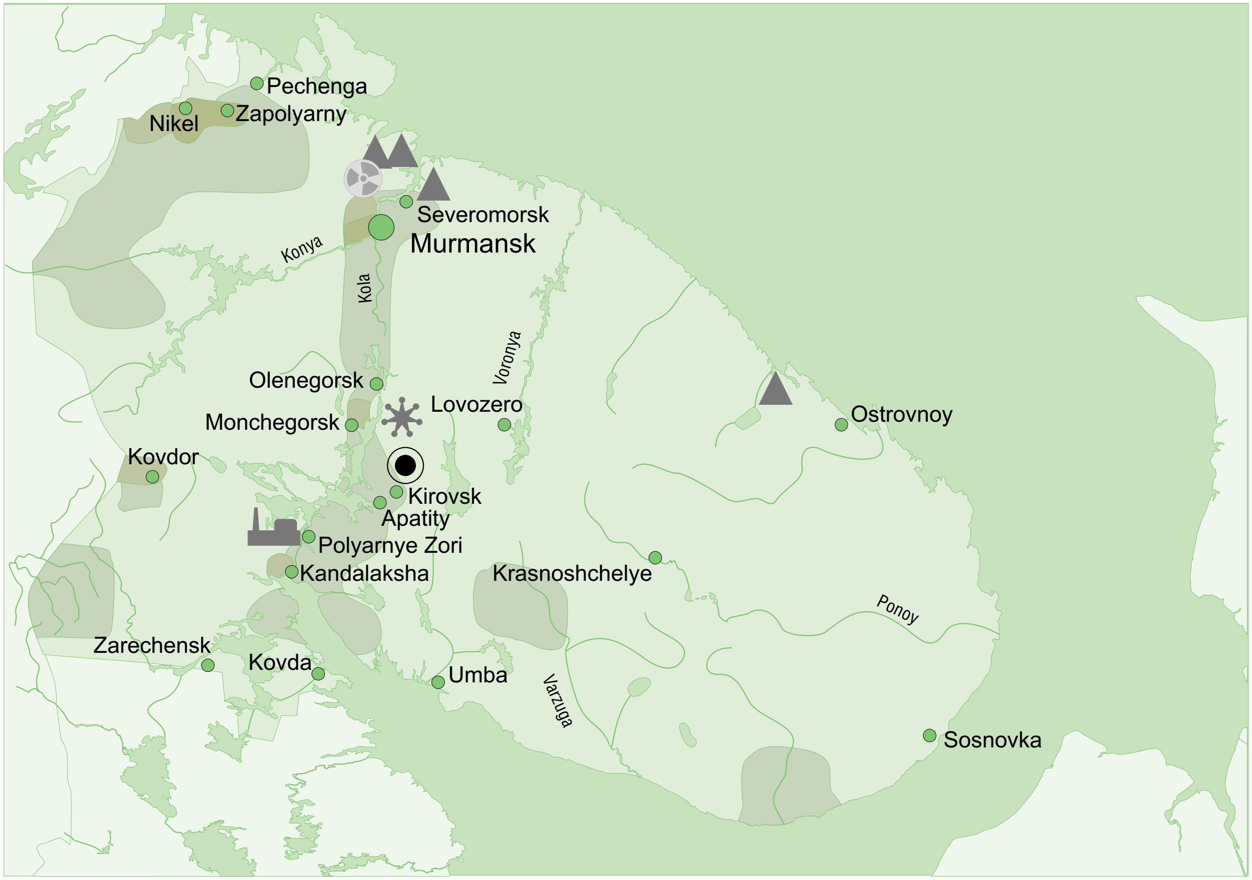
The suspended particulate air pollution is the most hazardous among risk factors dealt with the activity of industries in big cities of the Murmansk/Arkhangelsk regions.

The maximum estimated level of chemical non-carcinogenic risk in Kandalaksha makes up $8{\cdot}10^{-3}$. The risk of such a level is considered high; it is close to the value of an individual risk of death from chronic bronchitis or accidental death.

Risks of different chemical carcinogens are at the level of 10^{-7} up to 10^{-4}. Nickel compounds are the most hazardous — their estimated values for Kandalaksha make up $2{\cdot}10^{-4}$. This level is comparable to the risk of death from pancreatic diabetes or chronic alcoholism.

The radiation risk in the Kola NPP surveillance zone is at the lowest level ($4{\cdot}10^{-7}$). This risk can be compared to the risk of death from natural catastrophes or to the risk of radiography-based research.

Pollutant		Locality	Maximum Annual Death Risk
Suspended Particles		Kandalaksha	$8{\cdot}10^{-3}$
Nickel Compounds		Kandalaksha	$2{\cdot}10^{-4}$
Radiation	Kola NPP surveillance zone	Polyarnye Zori	$4{\cdot}10^{-7}$
	Global fallouts	Kola Peninsula	$6{\cdot}10^{-7}$



Map Legend

Pressure of Ecological Situation

[T. Makarova, Z. Makarova, G. Kalabin from the Institute of Industrial Ecology of the North from the RAS Kola Research Center, Apatity, 2000]

- 🟩 Extreme
- 🟩 High
- 🟩 Medium

Sites of Nuclear Complex

- ▲ Nuclear Power Installations (Sites of Basing)
- ☢ RW Surface Burial
- ✳ Sites of Peaceful Nuclear Explosions
- ◉ Uranium Deposits
- 🏭 The Kola NPP

Population

- ● More than 100,000 people
- • Less than 100,000 people

Kola NPP

The Kola NPP is the first Russian nuclear power station outside the Polar circle. The station is located on the shore of the Imandra Lake; the NPP staff includes 3,000 people. The city of Poliarnye Zori, where the NPP employees and their families live, is situated 15 km from the station.

The Kola NPP has four VVER-440 power units (similar to PWR type of reactor). The NPP thermal power established is 5500 MW, that corresponding to 1760 MW electric power. The first power unit was put into operation in 1973. The others began operation in 1974, 1981 and 1984.

VVER-440 water-moderated power reactors have proved, first of all, safe in operation. The same Soviet-produced reactors are installed at the Finnish Loviisa NPP (which is considered one of the most reliable in the world) and in the other countries of Eastern Europe, namely in Czech Republic, Slovakia, Hungary, and Bulgaria.

For 30 years of operation, the most vigorous trial for the Kola NPP was the March 1993 hurricane. The hurricane damaged high voltage lines within the Kolenergo power system, and as a result, the energy supply from external power sources to the NPP work, failed. The Kola NPP incident, complicated from a technical point of view (the third level by INES international scale for nuclear events, see page 21), did not impact the current parameters of the plant radiation safety and did not involve exposure of the personnel and the public.

As of today, the plant maintains the western NPP status, considering the limited number of operational failures. It is no wonder. Such results are possible due to massive investments into safety between 1989—2001, that amounting to, at least, 3.1 billion roubles. Increased safety for the 1st generation power units (the first and second units) cost approximately 30 times more than reconstruction of the 2nd generation power units (the third and fourth ones). Programs of technical assistance from the countries of Northern Europe and the USA secured approximately one-fifth of these funds ($30 million USD).

Safety Regulation

The design life of the NPP power units is 30 years. Upon comprehensive evaluation in April 2003, the nuclear regulator of Russia (Gosatomnadzor) confirmed that the plant's nuclear/radiation/technical/fire safety was ensured. The modernization of the 1st power unit, which has worked reliably and without failures through its 30-year design cycle, allows operators to extend its operational life

The economic development strategy for the Murmansk region envisages the start up of construction of the Kola NPP first power unit of the second line in 2010–2011 to be put into operation in 2015–2016.

Growth of industrial production and power consumption in the region is anticipated by that time. Upon modernization and expanding, the Kola power system will be able to provide for favorable sale of electric power excesses in Russia and abroad.

for another 15 years. Gosatomnadzor issued to the plant a license for the 5-year extension of operation for the first unit. Administrators will consider further extension in 5 years. The activities are presently under way to extend the operational life for the second power unit for the same 15-year term. The practice of extending the operational life upon expiration of the design term is accepted worldwide.

Spent Nuclear Fuel/Radioactive Waste Management

Spent nuclear fuel (SNF) technology for VVER-440 reactors is well developed and the required infrastructure exists. The Kola NPP RW management scheme is the same as that of the other NPPs with reactors of this kind.

SNF is stored in a special NPP repository for no less than three years and then it is shipped in a special transport cask by rail to a processing plant at the Mayak facility. Travel safety for the modern casks is very high. The cask remains sealed upon extreme impact, including when falling from a great height, at length sinking, and when on fire.

Radioactive waste (RW) generation is inevitable through NPP activity. Solid wastes (SW) comprise spent materials, facilities and equipment, not for additional use and in which radionuclide contents exceed levels established by the federal standarts/procedures.

The Kola NPP has at its disposal a few SW repositories for low level, intermediate level and high level wastes. The repository construction provides reliable and safe waste isolation from the environment. Prior to storage, certain SW's are processed by methods of incineration and pressing. As of today, the repositories are only half full. Sufficient space is left to dispose SW that result from the overall period of NPP operation.

The construction of a technological complex to process liquid radioactive waste (LW) has been

Extending the life of operating NPPs is one of the most important international trends for the current stage of nuclear power development. First, to extend operational life is the most efficient financial investment to preserve generating power. Second, the 30-year operational design for the Russian reactors was defined in 1950–1960s, when there was a lack of actual data on the wear of NPP equipment. The experience of NPP operation presently allows specialists to justify review of that term.

The two power units of the Novovoronezsh NPP, with similar VVER-440 reactor installations, were the first to get licenses from Gosatomnadzor of Russia, for extended operation.

The life extension for nuclear power units is widely used in the world practice of the USA, Great Britain and other countries. France and Japan are preparing for such activities. For instance, in the USA, 30 nuclear power units gained permission from the US Nuclear Regulatory Commission for the last four years (2000–2003), to extend their life from 40 to 60 years. In 2004, another eight owners of NPPs are expected to submit requests.

under way at the NPP. There, operators will concentrate and harden contaminated solutions. LW transfer to the hardened state decreases opportunities for radionuclide migration into the environment, and greatly decreases radionuclide volume.

Part of the complex technological systems will be delivered to the Kola NPP within the scope of international cooperation (the TACIS program). The complex is planned for commissioning by late 2005.

Radiation Safety

Radiation safety at the NPP is assessed, first of all, by personnel exposure level and by radioactive substance releases/discharges into the environment.

The Kola NPP employees' exposure doses have regularly decreased for the last 5 years. If the average annual dose was 4 mSv in 1994 (at the 50mSv/year sanitary standard for the staff), it decreased to 1.8 mSv in 2002 (at the new standard of 20 mSv/year). The Kola NPP by personnel exposure is at the level of the world's top-performing NPPs.

It should be noted that the new sanitary procedures for the NPP design and operation have tightened standards on the NPP total radiation impact on the public and the environment. The permissible dose load stipulated by gas and aerosol releases or liquid discharges is established as 20 μSv per year. Health risks are considered negligibly low at such dose.

Gas and aerosol releases from the Kola NPP recently have been less than the new permissible values. For instance, the actual volume of radioiodine release was 23% in 2001 and that of inert radioactive gases was 7% of the permissible standard.

The liquid discharge activity also was less than the permissible limit. For instance, in 2001, the water discharge activity of such radionuclides as cesium and cobalt was respectively 12 and 20 times less than the standard.

Nuclear safety is the status of immunity from an occurrence of spontaneous chain reaction or its uncontrolled passage.

Radiation safety is the status of protection for the personnel, population and environment from harmful radiation effects.

Accident Forecast and Prevention

When designing the NPP, a very wide range of initial events and probable ways of accident development is considered and analysed. For each of them, the design envisages extra safety systems and protective barriers. If an accident takes place due to the events not taken into account by the design, it is called a «beyond-the design-basis» accident. There is a rule that works for the NPP: the more severe effects of the accident, the lesser the probability of its occurrence should be.

Five levels of protection are envisaged to prevent severe emergencies at the NPP:

- Automation, technological protection and blockage supporting the block under normal operation;
- Safety systems revealing and preventing development of deviations from normal working conditions;
- Technical facilities for accident management and emergency action procedures designed for various emergency symptoms provide accident elimination within safe operation;

- Emergency action plans preserving the efficiency of physical safety barriers remained intact after the accident;
- Actions to protect the public and environment in case of severe accidents (See page 36).

Apart from that, the NPP protective system comprises actions mitigating the probability of the personnel’s errors (for instance, appropriate organization of activities and control over operation performance; training; psychophysiological checkups; and safety culture increase).

One may find more details about provision of emergency preparedness in case of radiation accident at the Kola NPP in the Section «Emergency Response».

International Nuclear Event Scale

The NPP accident severity is estimated by the International Nuclear Event Scale (INES), the level of hazard being reported to IAEA and to the national/international mass media. The INES scale has 7 levels. There is no hazard for the public at level 1 and 2. Safety barriers are considerably damaged at accidents of level 5 and beyond. The Chernobyl accident is related to level 7, the most hazardous.

Radiation Monitoring

Regular monitoring of the radiation situation on the Kola Peninsula and that of the neighboring water areas is performed by the Murmansk territorial subsystem of the unified state automated system of control over the radiation situation (**ARSCS**) on the territory of the Russian Federation.

The ARSCS Murmansk territorial system obtains data from the Roshydromet regional service, the Kola NPP Information/Analytical Centre and from the ARSCS Federal Centre. Automatic data acceptance takes place 24 hours a day. The ARSCS system transfers the operative data to the state authorities concerned, namely: Natural Resources Committee, Civil Defense/Emergency Central Department, and the Centre of State Sanitary-Epidemiological Surveillance over the Murmansk region.

Information about the current radiation status in the region is available to the public on the Internet site of the Murmansk territorial environmental hydrometeorology/monitoring department, (www.murman.ru/kolgimet/). One can find the data on measurements made in immediate vicinity to nuclear and radiation-hazard facilities on the site of Situation-Crisis Centre (SCC) of MinAtom of Russia, (www.minatom.ru), in the section titled «Radiation Monitoring».

A decision to create the «Arkhangelsk-ARSCS» system in the Arkhangelsk region was made in May 2003. The Northern territorial environmental hydrometeorology/monitoring department presently performs monitoring over the radiation situation on the territory of the region. Regular measurements for the gamma-radiation level are made at point 31 of the stationary observation network. The respective services also perform observation at nuclear and radiation-hazard facilities in Severodvinsk («Zvjozdochka» facility and «Sevmashfacility»). Local sanitary and epidemiological services and Research Institute «Prometei» run radiological inspections of these facilities' radiation-control area and surveillance zone. When the «Arkhangelsk-ARSCS» system operates, both state and departmental structures that monitor radiation will merge into a unified information network that will enter the all-Russian ARSCS system.

Automated control of the radiation status stability in the ARSCS system is performed by dosimeters. These devices show the dose rate, i.e. the dose one can obtain for the unit time (more often, for an hour). Up to now, there are devices measuring the dose rate in the out-of-date units, such as «microroentgen/hour» (μR/h). It is very simple to convert their indications into modern units, for instance: $1 \mu R/h = 10^{-5}$ mSv/h. Dosimeters are widely used, and those who wish may acquire a personal dosimeter.

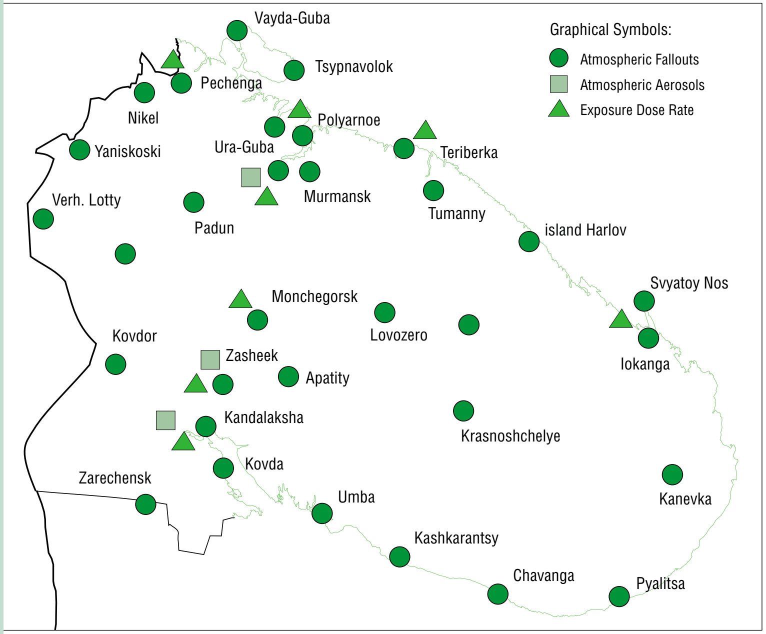
The exposure dose is estimated by means of multiplication of the dose rate by the time during which the individual has been under exposure. Let us recall the fact that probable adverse exposure effects mainly depend on the dose obtained.

For instance, the inhabitant of the Monchegorsk city, where the dosimeter showed the dose rate of 11 μR/h during a year, will obtain the 1 mSv dose.

The Murmansk Territorial Automated Radiation Status Control System; Data Fragment from the Site: www.murman.ru/kolgimet/

Exposure Dose Rate (μR/h) in the Murmansk region, as of 11:00 a.m. (September 9, 2004)

Sites	Station Code	Exposure Dose Rate	
		Time	Value
Murmansk Region	91012	11:00	11.4
Alakurtti	22301	10:00	11
Apatity	22213	10:00	9.8
Barentsburg	20107	10:00	12
Kandalaksha	22217		
Kanevka	22249	10:00	15
Kashkarantsy	22334	10:00	8
Kovda	22312	10:00	8
Kovdor	22204	10:00	5
Kolm-yavr	22232	10:00	15
Krasnoschelje	22235	10:00	11
Lovoozero	22127	10:00	5
Lotta	22100	10:00	9
Monchegorsk	22212	10:00	11
Murmansk	91001	11:00	5.2
Murmashi	22114	10:00	11
Nivankyul	22105	10:00	9
Nickel	22004	10:00	9
Padun	22106	10:00	9
Poliarny	22019	10:00	9
Vaida-Bay	22003	10:00	10
Yiokanjga	22149	10:00	10
Zarechensk	22302	10:00	10
Zasheek	22214	09:00	10.1



Graphical Symbols:

- ● Atmospheric Fallouts
- ■ Atmospheric Aerosols
- ▲ Exposure Dose Rate

The dose rate on the Kola Peninsula ranges from 3 to 25 μR/h.

The dose rate within the 100-km zone of the Kola NPP ranges from 5 to 15 μR/h. The parameters of the Kola NPP ARSCS system are established at the levels as follows: alert signal setting — 33.00 μR/h; and emergency signal setting — 2000.00 μR/h.

Complex Utilization of Nuclear Submarines

Issues and Solutions

Nuclear submarines (**NS**) and surface vessels (**SV**) with nuclear power installations, as any complex equipment, have a defined resource. Their service life makes up 30—40 years, and when it expires, they are subject to decommissioning and recycling. The USSR defense programs formed during the «Cold War» envisaged only nuclear-force buildup. NS decommissioning, SNF/RW management, and the creation of required infrastructure long remained lesser priorities.

The situation changed with the end of the arms race, when the USSR assumed the obligations to reduce the nuclear arsenal and the military nuclear fleet. Managers were challenged with safe recycling of NS and facilities containing considerable radioactive material amidst drastic funding cuts. At the same time, probability of extraordinary occurrences, including those with possible adverse environmental effects, grew with the time.

The work scale, duration and complexity made NS recycling a priority national task in Russia. The 1995 RF President's Decree gave the NS recycling program a presidential status. However, heavy economic burdens impeded provision of required resources and proper organization of the work.

NS Number (Nothern and Pacific Fleets)	Before 1998	By End of 2003
Decommissioned	177	193
With SNF unloaded	53	123
Recycled	39	94

A special Governmental Decree «On Actions to Accelerate the Utilization of NS/SV with nuclear power installations decommissioned from the Navy as well as the environmental remediation of the Navy's radiation-hazard objects» was issued in May 1998. The Russian Federation Ministry of Atomic Energy was assigned as the State customer-coordinator of activities relating to the issue. The situation has radically changed since that time.

While until 1998, only one-fifth of the decommissioned NS were recycled, almost half from the increased number of retired NSs were recycled by the end of 2003. The potential hazard from a submarine subject to recycling is substantially lower if its spent nuclear fuel is unloaded. 70 NSs have been unloaded in past five years, while only 53 were unloaded during the overall previous period.

The concept for NS complex utilization, as applied to the new economic and political conditions, was developed in 2001. It takes into account domestic and foreign experience and meets the interests of both national and international safety, including physical protection and non-proliferation. The new technical policy envisages that utilization of NS and vessels of atomic technological service, as well as remediation of radiation-hazard facilities at coastal sites of basing will operate to mitigate hazards at all stages of related activities. Operation also will involve economic use of the secondary resources and equipment obtained upon recycling. These activities will be funded out of the federal budget and within the scope of international cooperation.

Today there are nearly a hundred NS and several tens of technical service vessels (28 are in emergency status or sunk/half-sunk), subject to recycling in the North region. The land-based infrastructure that supports NS recycling in the region includes floating vessels in the Andreev Bay and Gremikha settlement, and docks of Murmansk, Severodvinsk, Poliarny, and Snezshnogorsk.

NS Recycling Process

For recycling, nuclear submarines are transported from the berth to the dock. Many NS remaining on the berth for a long time have lost their leak-proof seals and in order to transport them the flotation recovery or use of special docks or pontoons is required. It is a complicated task and, if not properly tackled at the organizational-technical level, the NS may sink, as happened with the K-159 vessel, in August 2003.

The initial recycling operation is to unload the spent fuel assemblies from NS. This is one one of the important and potentially dangerous operations; therefore, the unloading technologies are agreed with control and supervision authorities. Workers withdraw the fuel assemblies from the core and place them into casings in a floating repository. The vessel delivers the casings to a railroad terminal, where workers reload them into shipping casks. Afterward, workers load the casks into special railcars that travel outside the region for processing, to the «Mayak» facility (the Chelyabinsk region) without intermediary storage in coastal sites of basing.

Since November 2003, an opportunity has arisen to store the casks at a special land-based site of the «Atomflot» facility. The site was built within the framework of the «Arctic Military Environmental Cooperation» program (AMEC). The site can simultaneously store 19 casks, which are estimated to keep SNF within the period from 5-50 years. After storage, the SNF is transported to «Mayak». The site has a number of advantages, namely: uninterrupted work and increase of the NS fuel unloading rate. The program has achieved the optimal SNF unloading rate, at 15 reactors per year.

After the SNF unloading, workers cut out the reactor block (that frequently consists of three compartments: the reactor and two adjacent sections). Workers perform the work at a floating dock. Such technology prevents radioactive contamination of the dock's water area. A three-compartment block is launched and tugged to the Saida Bay, where blocks are temporarily stored afloat until special site construction on land. The construction of such site is presently under way in the Saida-Bay.

NS is no longer a nuclear hazard after SNF unloading.

NS parts remaining after segregation of the reactor block do not represent a radiation hazard either; therefore, they are subject to recycling.

The reactor block cannot remain afloat infinitely. Upon creation of the special site, all reactor blocks will be transferred to the land within a few years.

The USA, where the NS utilization also is under way, but the number of submarines subject to recycling is much less, have accepted a similar utilization concept. The removed reactor compartment (with the preliminarily unloaded SNF) is loaded onto a barge and transported to long-term storage. There, it is installed on a concrete base, where it will remain for tens or hundreds of years, until its internal radioactivity decreases.

After expiration of a long period, it will become possible to perform segregation of the reactor blocks, i.e. the equipment dismantling and meltdown, to re-use the metal. The longest term for intrareactor construction storage until recycling makes up 700 years.

Being at a special site under control, the reactor blocks present a hazard to neither the public nor the environment. Therefore, the item of their recycling deals with economic expediency (the ratio between the term of storage and prices for metal, etc.).

At the current rate, by year 2010 all decommissioned NS can be recycled and their reactor blocks can be placed in a special repository for long storage.

Possible Emergencies

When using radiation-producing equipment, as with any other activity, malfunctions can occur. Malfunctions can be due to equipment failures, or personnel errors, or due to natural disasters, etc. If resulting human exposure exceeds established standards and/or radioactive contamination of the environment occurs, administrators will speak of a radiation accident. What radiation accidents may occur during NS recycling?

Loss of control over equipment is the most probable situation. For instance, workers might mistakenly scrap radioactive metal. Such an event would be revealed at one of the shipping stages, but unsafe human exposure could occur in the meantime. Other emergencies do not present such hazards to the public. They may involve personnel exposure or contamination of the prohibited industrial site area, where the recycling activities are under way.

What is the basis for such assertions? They are justified by the fact that solid or liquid RW provide the overwhelming risk of radioactivity. The number of gaseous radioactive substances is rather low in the recycled objects. The solid RW are localized and cannot, in principle, spread in the environment. The liquid RW spread happens rather slowly. Pure waters quickly dilute them, greatly mitigating the hazard.

Only through airborne radioactive spread may the territories distant from the industrial site be subject to radioactive contamination. Therefore, the processes owing to which nuclear fuel can be dispersed (turned into fine aerosols) represent the most hazards.

The fuel may happen to be airborne only at severe accidents accompanied by an explosion or a conflagration. The potential hazard accident is most likely associated with operations to unload spent fuel assemblies from the NS reactor installations.

Nuclear accidents at the decommissioned NS are hardly probable and their effects cannot reach the level of the Chernobyl catastrophe. First, upon submarine decommissioning, the reactor installations are blanked-off for a long time. For that period, the majority of radionuclides decay, including the short-lived ones. If the spontaneous chain reaction happens to take place, the formed quantity of radiologically-hazard radionuclides, such as radioiodine, is relatively small. Regarding radiocesium and other longlived radionuclides, one can take efficient protective actions.

Specialists take into account all types of emergencies, including the personnel errors, natural disasters, aircrafts' impacting the area, etc. Although the probability of such situations is low, preventive actions to exclude them or mitigate the probability of their occurrence are developed.

The scale of emergency effects during the work with NS at dockyards can be assessed by the INES scale.

The maximal «design» accident envisages occurrence of the fire in the reactor compartment during the vessel recycling at an open stockpile site (owing to violations in the technology or due to the personnel's errors). The effects may reach the 4th level by the INES scale (See p.21).

«Beyond-the design-basis» accidents may occur due to the personnel's gross errors, sabotages, aircraft crash, etc. During the maximal «beyond-the design-basis» accident (occurrence of the fire when the vessel is under recycling at the stockpile site, or that of spontaneous chain nuclear reaction when the vessel is in the plant's water area) the effects, in principle, might be hazardous to the environment (the 5th level by the INES scale). Let us recall once more that the Chernobyl accident is related to the maximal 7th level of the scale (See page 21).

Other Issues

Surface Nuclear Vessels. As in case with NS, nuclear reactors of surface vessels are located in a separate compartment. Special protective barriers are envisaged, as in the submarine, to prevent radioactive substance releases into the vessels' premises and into the environment. Issues of recycling for such vessels are similar.

Vessels of Atomic Technological Service (ATS) provide the loading of NS and surface nuclear vessels with fresh fuel and also are used for acceptance of spent fuel and LRW. In total, 41 ATS vessels are decommissioned and subject to recycling under individual projects and technologies that state managers and safety regulators jointly approve. For instance, the «Lepse» mother ship has been in operation for more than forty years. It has been used for the past twenty years only as a repository for irradiated fuel and radioactive waste. Long storage has involved metal corrosion; therefore, general technologies to extract fuel assemblies with spent fuel from the repository are inapplicable there. The Lepse recycling is estimated as 30 million euro.

In 2003, the international program on the Lepse complex utilization was launched. The countries of the European community and those from the Northern ecological financial corporation undertook funding. French/English/Russian specialists will run the activities on SNF unloading. Complete recycling of the mother ship will take three or four years.

RW/SNF Management. The issue of RW/SNF management has been neglected for a long time. As a result of nuclear vessels operation and utilization, the land bases and ATS vessels have a huge amount of SNF and liquid/solid RW accumulated. A number of repositories of coastal technical bases do not fully meet current requirements for provision of nuclear and radiation safety.

The bases often lack technical safety barriers as exist in NS (base structures of the reactor installation/reactor compartment, strong vessel hull). Therefore, SNF/RW materials in storage at the former fleet bases are the most vulnerable with respect to anthropogenic, natural or terrorist threats.

Minatom of Russia has started to make active efforts to solve the above-mentioned issues within the scope of activities on NS recycling. The following has been done:

- Commissioning of stationary complexes for solid/liquid RW processing at the «Zvjozdochka» facility (Severodvinsk) supported by the US program «Joint Mitigation of a Threat»;
- Inhancement for the LRW processing installation at the «Atomflot» facility (Murmansk) through financial support of Russia/Norway/USA;
- Putting into operation of the mobile installation to process LRW in the Murmansk region; and
- Commissioning in 2004 of the first point for processing vessels' solid RW at the dock in the Poliarny city, under the AMEC military cooperation program (including Russia/USA/Norway).

Due to commissioning of the above-mentioned complexes/installations, all LRW forming during the recycling of NS and vessels are processed and conditioned. The total volume of previously accumulated waste gradually decreases. Further accumulation of vessels' solid RW is excluded, though

The North Fleet Bases:

1 — Western Litsa Bay;
2 — Olenja Bay and Saida Bay;
3 — Ara Bay;
4 — Pala Bay;
6 — Iokanjga.

Site of settling/recycling for the Navy's decommissioned vessels and ships with nuclear power installations:

4 — Poliarny;
6 — Iokanjga;
7 — Murmansk («Atomflot» repair facility); and
8 — Severodvinsk.

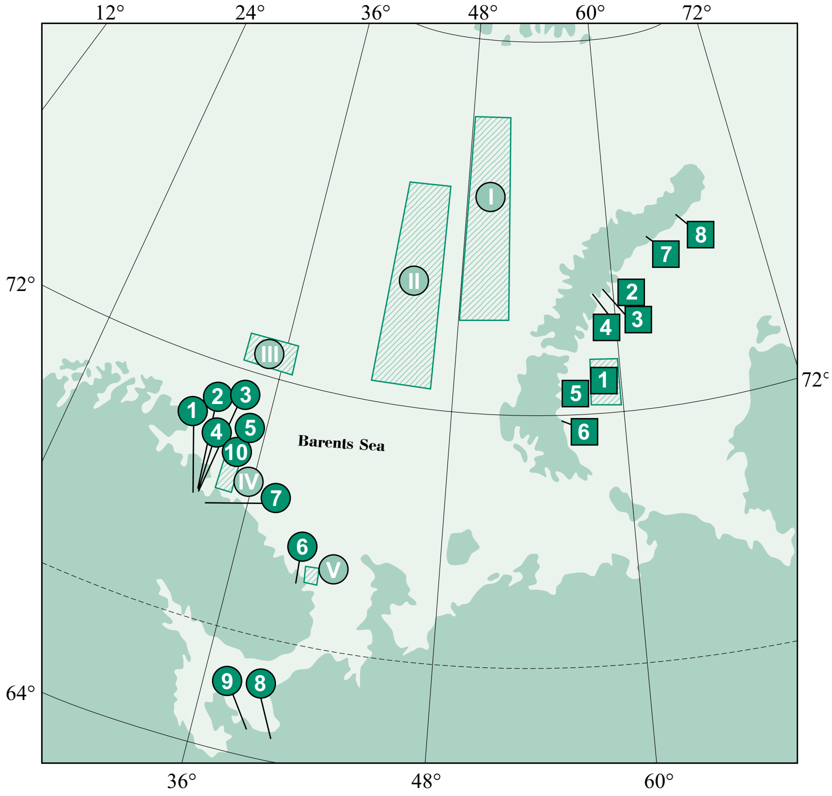
Sites of SNF temporary storage:

1 — Western Litsa Bay;
2 — the Navy's mother ship to reload the atomic submarine reactors;
6 — Iokanjga; and
7 — Mother ships «Imandra», «Lepse», «Lotta».

Shipbuilding plants/Dockyards:

4 — Poliarny (the Navy's dockyard) and Viuzshny (the «Nerpa» dockyard); and
8 — Severodvinsk («Sevmashpredpriatie» facility; «Sever» facility).

I–V — Liquid Radioactive Waste discharge areas.



Location of RW Basic Sources (● ○) and Sites of Their Burial (🟩) in the North Seas

V. Dovgusha, M. Tikhonov. Radionuclides in the North-West Region //News Summary, CRIatominform, 2002 the items of RW management are still acute. Regional centres for processing and long-term storage of conditioned wastes should be created to transfer into a safe condition the low-level and intermediate-level solid RW accumulated at the docks and the coastal floating bases.

To solve the issues of SNF management, the following has been recently done:

- Putting into operation of the land-based complex for SNF unloading from NS reactors at the «Zvjozdochka» facility supported by the US program «Joint Mitigation of a Threat»;
- Implementation of the technology for SNF «dry» temporary container storage. For that purpose, new metal-concrete containers to store and transport SNF are produced and a site for their temporary storage is built. A site to reload SNF containers is commissioned at the «Atomflot» facility supported by the AMEC program; and
- To accelerate the SNF transfer to the «Mayak» facility, the two special trains with the SNF containers are produced and commissioned through financial support of Norway/USA.

Since 2000, all activities on remediation of RW/SNF storage sites in the region have been conducted by a new facility «SevRAO» (Murmansk) established by Minatom of Russia. In 2001, SevRAO began to recover the physical defense systems and to mitigate an ecological hazard from nuclear- and radiation-hazard facilities located at the Navy's former coastal bases (the Andreev Bay and the Gremikha settlement). For instance, in 2003, detailed radiation survey of the lands was performed as well as big-volumed solid RW was fragmented, collected from open sites, packed and placed into the repository, etc.

As a result, SevRAO has succeeded in improving to some extent the radio-ecological situation in the above-mentioned sites. The facility's nearest plans envisage recovery of the infrastructure providing for safe conditions of the personnel's work; complex engineering-radiation survey of the buildings/constructions/sites for subsequent selection of an optimal and safe option for their remediation; and creation of essential technical means, etc.

International Cooperation Programs

Russia is actively involved in the international system of agreements, treaties and conventions. The involvement covers both general items with regard to provision of nuclear/radiation/ecological safety, when using the atomic energy, and the items directly dealt with recycling and remediation of radiation-hazard objects decommissioned from the Navy and the nuclear civil fleet. Cooperation in this field started in 1991.

Within the scope of the American-Russian non-proliferation program launched in 1991, the Navy obtained $2.3 billion to eliminate the strategic NS. The governments of the United Kingdom/Norway also rendered a considerable financial and technical assistance.

At present, the northern countries are more concerned about problems that originated by mass decommissioning of the Russian nuclear fleet. Foreign countries invest funds to ensure environmental safety when recycling Russian NS, managing RW/SNF, and operating the Kola NPP. For the past five years, Norway, USA, Germany, Finland, UK, France, and Canada have rendered technical assistance to the nuclear complex facilities in the Murmansk/Arkhangelsk regions, within the frameworks of bilateral or multilateral government agreements.

In 2000, the foreign partners of Russia merged within the scope of a new initiative titled «Northern Dimension Environmental Partnership» (NDEP), the aim of which is to coordinate international assistance, define its priorities and finance selected projects.

An agreement for implementation of the Global Partnership program against proliferation of mass destruction weapons/ materials was achieved at the G8 summit in June 2002. The program amounting to $20 billion is planned for ten years. NS recycling is one of the program trends. By 2020, Russia will have to recycle about 200 NS, including those available at the Kola Peninsula bases.

Creating favorable conditions for foreign investments into radiological and environmental projects requires legislative provisions, for favorable legal and customs procedures. The Agreement on Multilateral Nuclear and Environmental Program in Russia was signed by Russia in 2003 and ratified in 2004. The Agreement is aimed at solving legal issues in programs of international cooperation in the abovemention field. This Agreement is the most significant from the standpoint of organizing practical activities in the Northwest region.

The Global Partnership Program (NDEP) ranks nuclear and environmental issues very high. Two-thirds from the NDEP Fund are aimed to solve those issues. Apart from that, Russia not only obtains the Fund's financial support but also invests into it.

The first step in that direction has become the development of a strategic plan which defines an overall picture of the work and precisely points out what has been done and what is to be done for each specific project proposed.

Development of the plan started in 2004. To secure the most objective picture, the Federal Agency for Atomic Energy (RosAtom) involved three different executors, such as the planing research institute NIKIET from RosAtom, IBRAE from the Russian Academy of Sciences, and the independent Kurchatov Institute. Such plan is essential for Russia to accept strategical decisions in the field of RW/SNF management.

Unified State System

The unified state system for prevention and elimination of emergencies (**RSE**) was established in 1994 to unite efforts, forces and means of the authorities of different levels and facilities that are charged to protect the public and territories. The RSE structure comprises two subsystems: territorial and functional.

The territorial subsystem maintains five levels: federal, regional, territorial, local and objective. The appropriate Emergency Commission is responsible for organization of emergency activities at each level.

The profile ministries and departments have the RSE functional subsystems. Their task is to supervise and control the status of environment and situation at potentially-hazard facilities, as well as to protect the personnel and the public. In case of a catastrophe that affects a few regions or neighboring countries, the RF Government Inter-departmental Emergency Commission begins work.

The RF Emergency Ministry (EMERCOM of Russia) manages the RSE.

The center to manage crisis situations is set up in EMERCOM of Russia for everyday control of emergency forces and means. The center is activated 24 hours a day, and can organize immediate response to any emergency. An operative shift on duty can simultaneously collect information on two or three emergencies at the federal or regional level.

Emergencies at nuclear complex facilities (or during transportation of radioactive substances) force the Branch System of Emergency Response of Russia's MinAtom (the present RosAtom) to act to eliminate emergencies and protect personnel. All actions outside the control zone of the facility are the RSE prerogative.

Whom should one contact in Moscow in case of emergency?

The Ministry of the Russian Federation for Civil Defense and Emergencies www.mchs.gov.ru	Inquiry Office	(095) 926-3901 info@mchs.gov.ru
	Public Relations/ Information Department	(095) 926-3500; (095) 926-3509; (095) 926-3940; (095) 923-5745 (fax)

Territorial Subsystem

The North-West Regional Civil Defense/Emergency (CD/E) Center is located in Saint Petersburg. In case of emergency, the Regional EC coordinates activities of the territorial subsystems at a regional level, and the Regional Central CD/E Department gets involved in the everyday activities.

Options for emergency response by all services are established and understood. They are developed by specialists of Central CD/E Department and are at the disposal of the EC. Depending on specific circumstances, various options are involved. The plans to prevent emergencies and to protect the public are agreed with the territorial bodies of Gosatomnadzor, Gosgortechnadzor and Sanepidnadzor, and other divisions or services of the functional subsystem.

The Arkhangelsk Central Department comprises the CD/E structural subdivisions (affiliates) in the cities of Arkhangelsk, Kotlas, Novodvinsk, Severodvinsk, and Koriazhma.

The following example demonstrates the current activity of the RSE regional subsystem in the Murmansk region. In 2003, the list of regional hazardous productions subject to safety regulations was approved. The list covers three joint-stock companies («Apatyt», «Belomor Oil-Tank», and «Kola Hydrometallurgical Complex»), which are located in the cities of Kirovsk, Apatyty and Monchegorsk, as well as in the Pechengsky district.

Administrators of the regional cities/districts are expected to systematically consider at the EC meetings the process of safety declarations for the listed sites and to take required actions to enhance the activity and strictly observe the term for developing safety declarations. The authorized bodies are expected to issue licenses to operate hazardous sites per the appropriate declaration made in compliance with standard regulations. Respective regional departments (Central CD/E Department, Gosgortechnadzor, Gosenergonadzor and Environmental Resources/Environmental Protection Department), are assigned to control the declaration development with regard to adherence to the dates.

Whom should one contact in case of emergency?

Central Department for Civil Defense and Emergencies (CD/E) in the Arkhangelsk region	Reception Room	(8182) 651-494 (fax)	27, Svobody str., Arkhangelsk 163000
	Operative person on duty	(8182) 646-001	
	Head of the Arkhangelsk CD/E Department	(8182) 205-467	

Kola NPP

The Kola NPP emergency plan envisages a precise procedure for declaring such states as «Emergency Preparedness» and «Emergency Situation», as well as for enacting the «Plan of Actions to protect the Kola NPP personnel». Immediate notification is the most vital action in an elevated state. In compliance with regulations, the shiftman of the plant who receives a message about a possible radiation-hazard situation or an accident shall report to:

- Dispatcher on duty from Rosenergoatom;
- Civil Defense/Emergency Department of the Poliarnye Zori city;
- Central Civil Defense/Emergency Department of the Murmansk region;
- Situation-Crisis Centre of MinAtom of Russia.

The Poliarnye Zori administration has developed a plan of protection for the population from Poliarnye Zori and other localities within a 30-km zone of the NPP. Action plans to protect the personnel and the public are correlated to timely notify of an accident threat (event); as to volume/frequency of current information transmission; and coordination of actions and mutual aid in implementation of measures envisaged.

Ten loudspeaker devices and three electric sirens are activated to alert residents from Poliarnye Zori. The local broadcasting system and cable television transmit the information of the emergency. Residents of the settlements are notified by the broadcasting communication lines. The information of the accident is also transmitted over the telephone to the heads of facilities.

In case of an accident, the public finds sheltering in available protective buildings, basements adjusted for sheltering, as well as in residential and service premises. Protective plans provide for exits and the motor transport delivery, taking into account a simultaneous resettlement of the entire population.

The Rosenergoatom administration managing all Russian NPPs declares an immediate meeting in the Rosenergoatom's crisis center in Moscow, for the group that renders operative assistance to NPPs (OANPP). The OANPP group obtains on-line, basic technological and radiation parameters of all NPP sensors, by which decision makers can estimate the safety status of any power unit. The Moscow experts in the Rosenergoatom's crisis center at any moment can run a teleconference with the plant's emergency centre to specify the situation and develop countermeasures.

If the OANPP Group decides to involve one of the MinAtom's regional special emergency and technical centers, all special equipment available (robots, satellite and mobile communication facilities, protective facilities, etc.) immediately deploys to the emergency site. Upon arrival, personnel are ready to work «from the wheels». In case of an alert, the Defense Ministry engineering troops, or radiation and chemical protection departments located in the region may be used. If necessary, the OANPP group visits the emergency site and resumes an operative management of all forces and departments, in case of incompetent actions on the part of emergency manager.

Consistency among all departments and services develops through regular exercises and training. For instance, Rosenergoatom ran the latest emergency training at the Kola NPP in October 2003. The next course is planned for the summer of 2004, and in September Rosenergoatom plans a complex review of the Kola NPP.

Land-Based Sites of the Nuclear Fleet

Similar emergency exercises run at the other operating nuclear complex sites, including nuclear shipbuilding facilities.

The first North fleet's large-scale exercises to eliminate potential nuclear/radiation accident impacts took place in February 2000. Representatives of the Murmansk Regional CD/E Department and heads of administration from closed administrative and territorial formations (CATF) were involved in the exercises combined with the military. According to the exercise scenario, the fleet force was to mitigate accident impacts on the «Peter the Great» heavy nuclear missile cruiser. Fleet specialists in emergency-rescue, medical and chemical services, as well as radiation safety services, were almost fully deployed. Points of decontamination and points for rendering assistance to evacuees and injured people were set up at several sites around Severomorsk.

In September 2001, complex exercises ran to improve interaction between the fleet and civil defense forces in case of emergency, while the «Kursk» nuclear vessel was docked. The exercises were conducted on the CATF Severomorsk territory, which includes the Rosliakovo settlement, a location of the floating dock. Players notified the public using electric sirens, street loudspeakers and megaphones installed on the militia cars. The Severomorsk radio, the North fleet television and cable television of the Rosliakovo settlement broadcasted the operative information.

The probability for an accident on the «Kursk» vessel was negligibly low, as there were no activities planned for the reactor in the dock. Nevertheless, a plan for temporary resettlement of people from Posliakovo was developed. Nearly 11,000 inhabitants of the settlement were to leave the place by buses for safe areas, if necessary.

The most recent exercises in Severodvinsk took place in May 2003. According to the background information of the exercises, a radioactive substance release occurred at one of the nuclear submarines moored by the berth of Zviezdochka engineering facility, and a radioactive contamination threat resulted. The exercises started by switching on electric sirens at the facilities and in the streets of the city, and with transmission of a warning over the municipal radio communication lines. The commission comprising representatives of the municipality and the CD/E municipal department observed the subsequent player actions, and reported that everything had been done competently, by schedule and according to plan.

Whom should one contact in case of emergency?

Central Department for Civil Defense and Emergencies (CD/E) in the Murmansk region	Reception Room	(8152) 454-828 (8152) 453-659 (fax)	4, K. Burkova str., Murmansk 183025
	Operative person on duty	(8152) 473-906 (8152) 455-090	

RosAtom Branch System

Creation of the efficient system to prevent and eliminate emergencies at all nuclear-hazard facilities is one of the main lessons of Chernobyl.

In case of emergency at the nuclear complex facilities as well as when transporting nuclear materials and radioactive substances, the Nuclear/Radiation Safety Division of Russia's Federal Agency for Atomic Energy (RosAtom) is immediately involved in organizing the emergency actions. Its task is to mobilize RosAtom's forces and means.

RosAtom branch subsystem of RSE comprises five regional emergency technical centers equipped with state-of-the-art equipment and professional staff. One such center is located in the Urals, in the city of Snezhinsk. RosAtom can involve more than 300 qualified professional rescuers trained for radiation emergency conditions and up to 80,000 professional nuclear specialists in the activities at the emergency facility.

The Situation-Crisis Center (SCC) was established in RosAtom to efficiently address issues arising in crisis situations. The Center gathers all information on branch systems of the Automated Radiation Situation Control System (ARSCS). Apart from that, the Center maintains satellite communication with all branch facilities, and obtains the information about normal operation, contingencies and emergencies, 24 hours a day. In case of emergency, the SCC efficient-dispatch service reports to RosAtom management and appropriate services, providing them with information to make decisions.

Role of Local Authorities

In compliance with federal laws on radiation safety of the population and on protection of the public and territories from natural and human-induced emergencies, the local authorities act as follows:

Before the emergency:

- Set up permanent managing bodies specially authorized to tackle issues in the field of public protection;
- Train the public in preventive measures/actions in these situations;
- Prepare and keep ready all forces and means required;
- Create financial/material resource reserves to eliminate emergencies; and
- Economically promote the activity of natural/legal persons dealing with radiation safety provision.

During the emergency:

- Make decisions and organize evacuation measures;
- Organize and run the emergency-rescue work and other pressing activities, as well as support public order during their running;
- Notify and inform the public of potential hazards or emergencies; and
- Assist in stable functioning of facilities in emergencies.

After the emergency:

- Control radiation at the appropriate sites and take into account exposure doses to the public;
- Introduce particular treatments for the public living in the radioactive contamination zones;
- Enact measures to mitigate emergency consequences in appropriate areas;

- Control assistance rendered to the irradiated public; and
- Establish procedures for citizens' health indemnification and for paying damages for lost property.

The objectives for local authorities are, possibly, the most difficult, as these individuals approve or reject experts' proposed decisions regarding safety.

The experts forecast radiation situation development, estimate dose loads for the public, and prepare recommendations for public safety measures.

The local authorities make decisions, taking into account not only expert recommendations but also a variety of circumstances, including the interests of different people. For local authorities, the public risk perception is more important than the risk itself. Therefore, the local decisions do not always correspond to scientific expert recommendations.

Decisions on protective actions for the public are based on comparisons between predictable dose and emergency intervention levels. The intervention levels are defined so as to prevent clinical exposure effects. Thus, no cases of acute radiation sickness among the population in any nuclear facility emergencies, including Chernobyl, have occurred.

Evacuation is applied when the predictable doses are close to the level of clinical effects (50-500 mSv for the first 10 days). If doses are above 500 mSv, evacuation is obligatory; if doses are less, the experts make a forecast for a more remote period: a month or a year. If during the first month the doses exceed 30 mSv, a temporary resettlement is involved; the level of 10 mSv per month is established to terminate the period of temporary resettlement.

Sheltering is applied for the term of no more than 1–2 days in immediate proximity to the emergency location, if the dose predictable for the first 10 days is in the range of 5 to 50 mSv. Use of protective properties of buildings and constructions within the period of greatest exposure intensity (during the first hours after the emergency when the radioactive cloud appears over the locality) decreases the probability of residents becoming radiogenic cancer carriers.

Time of stable iodine pill consumption	Protection factor
During the inhalation	By 90 times
2 hours after the inhalation	By 10 times
6 hours after the inhalation	By 2 times

Iodine preventive measures. The NPP emergency release contains, as a rule, a great amount of radioactive iodine-131. Getting into the human body, via the unprotected respiratory system or with food, it accumulates in a thyroid gland and negatively impacts the function. The most effective safety method is the intake of medical products of stable iodine: potassium iodine in tablets or powders (iodine preventive measures). The maximum protective effect is achieved at preliminary reception of stable iodine or simultaneously with radioactive iodine. Iodine preventive measures decrease the doses of thyroid gland exposure by several times, thus mitigating the risk of developing thyroid gland pathology.

In the first days following the emergency, radioactivity levels in the environment decrease very quickly due to decay of short-life radioisotopes. Accordingly, basic exposure of the population falls on the first days. Therefore, decisions to take protective actions should be made quickly and implemented effectively. Any delay with respect to shelter, evacuation or iodine preventive measures in the early period gives rise to future problems, including social issues.

Radioiodine is hazardous in emergencies occurred at operating nuclear reactor. «Iodine hazard» significantly decreases, when the reactor is deactivated.

It is obvious that radiation preventive measures result in the disruption of normal lifestyles, changing the habitual course, economic and social functions. The interference entails not only economic damage but also adverse influence on public health, including psychological stress. The main principle of radiation protection is that damage decrease as a result of dose reduction should be sufficient to justify harm and cost of the treatment interference, including social cost.

Under what conditions is the harm from interference greater than the benefit of protective actions? Such conditions are clearly defined by the radiation safety standards (RSS-99). Two types of the intervention levels (level A and level B) are defined for a large-scale radiation accident. At dose loads above level B the protective actions are justified; at doses below level A, they will bring more harm than benefit.

In those cases when estimated doses are between levels A and B, the decision in respect of protective measures should be made with consideration of specific situation and local conditions, so that pure benefit of decreasing the dose would exceed to the maximum the damage from the interference. Let us consider the following example. Estimated doses are slightly higher than level A for evacuation, and the weather conditions are extremely adverse (hard frost). A responsible person should compare predicted radiation risks with anticipated damage from evacuation, including the number of those people who have caught cold or got pneumonia, etc. The right decision in this case might be strict adherence to the procedure of sheltering, rather than evacuation.

As emergency exercises show, in the above-mentioned case local administrators are inclined to make unjustified decisions, such as, for instance, resettlement of people from minimally contaminated lands long after the accident. In such cases, great resources are spent to prevent small collective doses. Measures taken soon after the accident make the maximum impact concerning radiological issues. Timely shelter of the population and running iodine preventive measures allow prevention of high collective doses, at lower cost.

Local authorities' competencies in making effective decisions increase considerably through emergency exercises and trainings. When organizing branch exercises at the RosAtom facilities, local authorities co-manage the events and are enabled to use to maximum state-secured resources for developing their territorial radiation-safety systems.

Therefore, one of the most vital conditions for enacting citizens' rights for protection of life, health and personal property in case of severe accident at the nuclear complex facilities is the interested attitude of local authorities to the emergency activities run at the RosAtom facilities.

Safety methods in case of radiation accident

☑ *Shelter in protective constructions or buildings with immediate sealing of windows/doors/air holes, etc.;*
☑ *Use individual means of protection (respirators, gas masks, and protective clothes and shoes, etc.);*
☑ *Use anti-radiation drugs;*
☑ *Exclude contaminated products and water from use;*
☑ *Evacuate people from contaminated areas;*
☑ *Restrict the access to the territory contaminated;*
☑ *Sanitize people, and decontaminate clothes, equipment, etc.*