

**MINISTRY OF THE RUSSIAN FEDERATION FOR  
CIVIL DEFENSE, EMERGENCIES, AND ELIMINATION  
OF CONSEQUENCES OF NATURAL DISASTERS  
(EMERCOM OF RUSSIA)**

**MINISTRY OF HEALTH AND SOCIAL DEVELOPMENT  
OF THE RUSSIAN FEDERATION  
Federal Inspectorate for Consumer Protection and  
Human Welfare (Rospotrebnadzor)**

# **TWENTY YEARS OF THE CHERNOBYL ACCIDENT**

**Results and Problems  
in Eliminating Its Consequences in Russia**

**Russian National Report**

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**1986–2006**

**Russian National Report**

Moscow, 2006

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1986–2006

Russian National Report

*Edited by S.K. Shoigu and L.A. Bolshov*

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## PREFACE



*RF Minister for Civil Defense, Emergencies  
and Elimination of Consequences of Natural Disasters  
S.K. Shoigu*

Twenty years have passed since the accident at the Chernobyl nuclear power plant. Today, it is not only a memorable date to us. We have survived the difficult years of success, errors and lessons. Proceeding from our experience, we should correct our goals and objectives aimed to mitigate the consequences of radiological emergencies and catastrophes taking into account the changes that occur in the country, first, in the economic sphere.

We can presently state that medical effects of the accident have turned out to be less severe than it was assumed earlier. The most scale accident consequences have realized in the social and economic

sphere rather than in radiological. At present, the items of social and economic remediation of the areas most affected by the accident should be viewed from the standpoint of mutual liability of the state and its citizens.

On behalf of the Russian Federation's Government, EMERCOM of Russia has been performing since 1994 the coordination of activities on elimination of the Chernobyl consequences. Within the scope of federal target program, a package of measures is being implemented at present to provide radiation protection for the public, social and economic remediation of the affected areas, and recovery of radio-contaminated regions for normal living and economic activity without any constraints by the radiation factor.

The Chernobyl consequences have remained actual for many thousands of Russian residents who live in radio-contaminated areas or who were directly involved in the activities at the power unit destroyed. The items of social protection for these people are the focus of attention of state authorities.

This Report prepared by the leading Russian experts covers the items of what has been done during the past years, how the Chernobyl consequences are assessed taking into account the experience gained, and what interpretation of the present situation and that of future work vistas is.

S.K. Shoigu,

RF Minister for Civil Defense, Emergencies  
and Elimination of Consequences of Natural Disasters

A handwritten signature in black ink, appearing to be 'S.K. Shoigu', written in a cursive style.



*G.G. Onishchenko, Head of the Federal Inspectorate for Consumer Protection and Human Welfare (Rospotrebnadzor), RF Chief Sanitary Officer, RAMS Academician*

Twenty years after the Chernobyl accident, above 1.5 million people in 14 subjects of the Russian Federation continue to live in the area of radioactive contamination. More than 180,000 of the Russians were affected by radiation, when participating in elimination of the accident and its consequences.

Since the first days of the accident, the public health service faced a task to develop and implement the measures on minimization of medical effects of the accident and public provision with medical assistance, including the employees of the nuclear power plant and the participants in mitigation of the accident.

The health of the liquidators and the public living in the contaminated areas is the most socially significant issue being solved in the process of elimination of the Chernobyl consequences. Radiological effects have

been the focus of attention for the overall 20-year period. The radiation protection system was based on performance of the two conditions, namely: absolute prevention of acute (deterministic) effects and reduction in the risk of remote (stochastic) effects to acceptable (justified) levels.

As early as in 1986, a decision was made to create the unified system of medical observation for the individuals affected by radiation as a result of the Chernobyl accident. The Russian State Medical and Dosimetry Register (RSMDR) was established on the basis of the Medical Radiological Research Center of the Russian Academy of Medical Sciences.

The two most suffered public groups were defined as a result of research activity of the Register. These are the children (at the moment of the accident) living in the highly contaminated areas and the liquidators who have obtained the exposure dose above 150 mGy.

According to the Register's data, 122 cases (54%) out of 226 thyroid cancers revealed during the years 1991–2003 among the children (at the moment of the Chernobyl catastrophe) from the Bryansk region can be considered as radiation-stipulated.

Hygienic regulation is one of the most important trends in protection of the public and the human habitat in radiological emergencies. This regulation has developed and improved along with changes in the radiation status, thus, fortifying the latter's improvements with a view to stabilize and normalize it through preventive/protective measures. Since 2002, the emergency standards have been abolished and replaced by the common federal ones.

Regardless of the measures for public protection and the remediation activity, the output of products exceeding the hygienic standards has been under way on the individual farms. The samples of such products reach 12% in the south-west districts of the Bryansk region. At present, the public exposure doses obtained in 425 localities of the Bryansk region and in 3 settlements of the Kaluga region exceed the established standard of 1 mSv; that requires the arrangements for and performance of a package of protective measures. At the same time, the radiation status has completely normalized in other 12 subjects of the Russian Federation.

To minimize medical effects, the Federal Supervision Service for Consumerism and Human Welfare (Rospotrebnadzor) considers it essential to continue a package of actions on health protection and medical rehabilitation of the public affected by radiation as a result of the Chernobyl acci-

dent, as well as to develop further epidemiological research to reveal radiological effects of the accident. The above mentioned remains the priority for the Russian preventive public health service.

G.G.Onischenko,

Head of the Federal Inspectorate for Consumer Protection  
and Human Welfare (Rospotrebnadzor),  
RF Chief Sanitary Officer,  
RAMS Academician

A handwritten signature in black ink, appearing to be 'G.G. Onischenko', written in a cursive style. The signature is positioned to the right of the typed name and title.

# CONTENTS

<b>PREFACE</b> .....	3
<b>INTRODUCTION</b> .....	8
<b>1. FIRST FIVE YEARS</b> .....	11
1.1. Technical Aspects of the Accident .....	11
1.2. Managing the Activities on Elimination of Accident Consequences.....	12
1.3. Measures for Public and Environmental Protection.....	12
1.4. Elaboration of the Strategy of Protective Measures under Conditions of Political Crisis.....	15
1.5. Creation of System to Manage Activities on Elimination of Chernobyl Consequences in Russian Federation.....	18
<b>2. RADIOECOLOGICAL ACCIDENT CONSEQUENCES</b> .....	19
2.1. Zones of Radioactive Contamination in Russian Federation .....	19
2.2. Modified Conditions for Public Life Activity.....	23
2.3. Agricultural Consequences .....	24
2.4. Forestry Consequences.....	28
<b>3. DOSE LOADS FOR PARTICIPANTS OF ELIMINATION OF ACCIDENT CONSEQUENCES (EAC) AND FOR PUBLIC</b> .....	31
3.1. Exposure Doses of Participants in Activities in ChNPP Zone.....	31
3.2. Public Exposure Doses.....	32
<b>4. MEDICAL CONSEQUENCES OF THE ACCIDENT</b> .....	35
4.1. Sufferers from Radiation Damages in the First Days.....	35
4.2. Results of Radiation and Epidemiological Research .....	37
4.3. Activity of Advisory Councils on Revealing the Causation between Diseases and Radiation Effects.....	43
<b>5. ELIMINATION OF CATASTROPHE CONSEQUENCES IN THE RUSSIAN FEDERATION</b> .....	45
5.1. State Programs on Elimination of Catastrophe Consequences .....	45
5.3. Social and Economic Development of Contaminated Areas .....	56
5.4. Social and Psychological Rehabilitation .....	59
5.5. Information and Analytical Provision of Activities .....	61

<b>6. DEVELOPMENT OF RF LEGISLATIVE BASIS IN THE FIELD OF SOCIAL PROTECTION OF CITIZENS SUFFERED FROM CHERNOBYL CATASTROPHE .....</b>	<b>65</b>
<b>7. CURRENT STATUS OF NUCLEAR AND RADIATION SAFETY IN THE RUSSIAN FEDERATION .....</b>	<b>69</b>
7.1. State Policy in the Field of Nuclear and Radiation Safety .....	69
7.2. Federal Target Programs .....	70
7.3. Status of Nuclear and Radiation Safety for Nuclear Power and Nuclear Industry.....	71
7.4. Enhancement of the System of Response to Radiological Emergencies .....	73
<b>CONCLUSIONS .....</b>	<b>78</b>
Prevention and Elimination of Radiological Emergencies.....	78
Results of Investigation of Accident Consequences .....	79
Efficiency of Protective Measures .....	81
Vistas .....	82
<b>REFERENCES .....</b>	<b>84</b>



## INTRODUCTION

Twenty years ago, the largest accident in the history of world nuclear power occurred at the fourth unit of the Chernobyl nuclear power plant. The lack of analogues in the world practice with respect to both severe destruction of the reactor and the scale of radioactive contamination of the affected areas and people required huge intellectual and material efforts of the country. Hundreds of thousands of citizens from the USSR, including nearly 200,000 people from Russia, were involved in the elimination of accident consequences during the first and the most acute period. Often risking their health, those people did their utmost to decrease sizeable consequences. Afterwards, all activities on radiation control, public exposure dose reduction, remediation of radio-contaminated areas, rendering medical assistance and social protection for the public suffered from the accident were implemented within the scope of state target programs.

Regardless of the multi-year efforts, some consequences of the accident have not been fully mitigated. However, it is of no doubt that the main goal to minimize health damage has been achieved. The Russian national report reviews in detail the results of the past twenty years and the current items.

To understand the main issues associated with elimination of the Chernobyl consequences, the objective analysis for the initial phase of arranging post-accident activities is required. Such analysis is represented in **Section 1** of the Report. The conclusion made due to consideration of technical aspects of the accident is simple. No such combination of the construction deficiencies and violations in the reactor management regulations resulted in the accident must ever take place not only when using nuclear power but also in any other kind of production activity.

Strategic errors in the arrangement of protective measures and recovery activities in the post-accident period should also be mentioned. Among them are as follows:

- Neglect of the need to run timely measures on the thyroid exposure prevention, first, among the children, in the initial phase of the accident;
- Unreal objectives as to rapid elimination of the accident consequences;
- Implementation of a large-scale relocation program in the period following the year 1988.

Being on the 20-year historical boundary, it is no less important to consider the Chernobyl consequences in the light of scientific objectivity. In no way belittling the services of the participants in elimination of the accident consequences and those misfortunes endured by millions of people, it is necessary to understand what is contribution of the radiation factor to public damage caused by the Chernobyl accident, first, in the health sphere. **Sections 2, 3 and 4** of the Report review in detail the radiological effects of the accident.

**Section 2** describes how radioactive contamination formed in various environments; how zoning of contaminated areas was performed within the boundaries of the former USSR; and how the radiation status changed with time. As forecasted, radioactive contamination of the Russian Federation's territory did not entail any serious changes in the status of wild life. Nevertheless, multiple constraints introduced by the authorities had a signifi-

cant impact on human living conditions, especially in rural areas. In many cases, restrictions were imposed on different kinds of economic activity, including in agriculture and forestry. The analysis has shown that sanitary constraints for the use or realization of contaminated foodstuffs have no less negative impacts than direct regulations or restrictions for certain kinds of economic activity.

**Section 3** is dedicated to the estimates of exposure doses; **Section 4** — to medical effects from the exposure obtained by the participants of activities in the zone of the Chernobyl NPP and by the public. The health status of the individuals affected by the accident is the most vital constituent in the assessment of accident consequences. Almost the 20-year work experience has shown that radiation has caused the following:

- 134 cases of acute radiation sickness among the firemen and the employees of the Chernobyl NPP being at the place of accident in the first 24 hours after the explosion. Out of this number, 28 people died during several months that followed the accident; another 19 persons died of different reasons during the subsequent 19 years;
- Up to half of 226 thyroid cancers revealed among the children and teenagers (at the moment of accident) from the Bryansk region in the period of 1991–2003. The survival after operations makes up 99%. As of today, only one child has died of all the children who underwent operations. The available causation between an abrupt increase in thyroid cancer among the children and radioactive releases during the accident is of no doubt for Byelorussia and Ukraine as well.

In addition, according to the data of the Russian State Medical-and-Dosimetry Register (RSMDR), several tens of leucoses resulted during the past years in death of the Russian liquidators who had obtained the exposure doses above 100 mSv might be associated with radiation. Overall, approximately 5,000 individuals out of this group of liquidators (about 60,000 people) have died of all the reasons during twenty years. However, the total death-rate among the liquidators does not exceed the corresponding values for the male population of Russia. The similar situation with respect to the total mortality is observed in the cohort of Byelorussian and Ukrainian participants in the elimination of accident consequences.

The overestimated number of people who died as a result of the Chernobyl accident and eventual confusion in the figures can be explained by the fact that thousands of the liquidators as well as people who resided in the contaminated areas have died due to natural reasons for the period following the year 1986. However, the anticipation of indisposition and the tendency to associate all health problems with radiation effects has created the situation when the number of deaths stipulated by the Chernobyl accident is considered to be higher.

On the Chernobyl Forum. Profound expertise for the overall volume of accumulated research data on the Chernobyl consequences for the public and the environment was conducted within the scope of the forum in 2003–2005. Leading scientists in the field of radioecology and radiation medicine as well as representatives of all profile international organizations, including the World Health Organization, were involved in the expertise. The subject-matter of Sections 2-4 of the National report corresponds to the items of the forum. Their content makes it possible to state that the basic work of Russian scientists is in principal accord with the forum's conclusions.

**Section 5** of the Report describes the results of the activities within the framework of the RF state programs; the priority trends and the results achieved, including the programs

for children's health protection, those of accommodation provision for the liquidators, and those of joint cooperation between Russia and Byelorussia.

The accident and the measures on its elimination have led to significant changes in the economy and social life of the most contaminated areas in the South-West of the Bryansk region. The items of economic development in the contaminated areas under new market conditions have long remained "off screen". The report, first, represents a detailed analysis of the entire set of problems being encountered every day by residents from the contaminated areas. Today's main issue is shown to be poverty which is rooted in the structure of regional economy. The low labour efficiency in agriculture, the townsmen who are out of job, and the resource flow-out entail an extremely low level of cash income. In its turn, the low income is a basic impediment to the development of local economy under new market conditions.

This section also analyzes social and psychological consequences of the accident that multiply exceed its radiological or eventual economic effects due to their coverage and public significance. The scale of social and psychological consequences is only partly explained by severity of the accident occurred. To a considerable extent, it reflects the public response to those unjustified management decisions that stipulated the involvement in the post-accident situation of millions of people who have begun to associate themselves with the "victims of Chernobyl" and to fear radiation and its health effects. At the same time, the Report underlines that people today are most concerned about economic difficulties, such as low living standards, unemployment and price increase. At this background, the Chernobyl benefits and the opportunity to be deprived of them, rather than radiation effects, cause such concern.

To conclude, a brief review is given as to the activities on the system analysis of accident consequences and information and analytical provision for federal programs. **Section 6** of the Report represents a condensed analysis of the legislative basis development in the field of social protection for the citizens suffered, and **Section 7** – the review of nuclear and radiation safety status in the Russian Federation. The **Conclusion** formulate the Chernobyl basic lessons, summarize the results of the 20-year work, and outline the ways to advance for the purpose of eliminating the accident consequences.

# 1. FIRST FIVE YEARS

Current understanding of the main issues associated with the elimination of radiation accident consequences envisages an objective analysis of the initial phase required for the arrangements of post-accident activities. The Chernobyl accident occurred in the USSR which management system had both well-defined advantages and serious deficiencies. The start-up of large-scale reforms in the country coincided in time with the Chernobyl catastrophe and imposed serious restrictions on the opportunity to make and implement effective decisions on the mitigation of accident consequences. By no means belittling the services of many thousands of participants in the catastrophe elimination, it should be noted that a number of serious errors was made in the initial period [1], mainly, in the field of decision-making.

## *1.1. Technical Aspects of the Accident*

The largest accident in the history of world nuclear power has become possible under conditions of available serious issues in the management and nuclear power safety regulation. The accident has occurred at the Chernobyl NPP power unit No.4 (the RBMK-1000 reactor) which industrial launch took place in December 1983. At that time, the scientists from the Kurchatov Institute pointed out that [2] during physical launches of the RBMK-1500 and RBMK-1000 of the second generation the effects of abnormal reactivity had been revealed, when control rods entered the core. They proposed the actions to eliminate the deficiencies. For the period of practical implementation of those actions, some restrictions for operative mode were offered.

On April 25, 1986, the employees of the Chernobyl NPP got ready for a shut-down of the power unit No.4 for routine repair during which an experiment was supposed to run. It was aimed at the equipment black-out and at using mechanical energy from the running-out of the turbogenerator rotor to provide workability for the power unit's safety systems. Due to the dispatcher restrictions, the reactor shut-down was postponed several times, having created certain difficulties in managing the reactor power. Regardless of the instructions, the operators extracted practically all control rods to support the required power, as well as a number of other major violations in the operative modes were performed, up to disconnection of the emergency protective systems.

At 1:26 on April 26, an uncontrollable power increase resulted in an explosion and a destruction of the considerable part of the reactor installation. As a result, hundreds of millions of curie of radioactive substances were released into the environment. In spite of evident seriousness of the accident and eventual extremely severe transnational consequences, the country's management did not take adequate actions in the first several days to inform the public and foreign countries. Moreover, the measures were taken during those days to classify the data on the accident consequences as secret.

The detailed analysis of the accident reasons jointly with the prediction of accident consequences, including health effects, was first submitted to the IAEA experts (Vienna, 25–29 August, 1986) [3]. The above materials were not published in the USSR. It served the basis for people to believe in mysterious accident reasons, though the results and con-

clusions made in summer 1986 with regard to the facts were fully confirmed and detailed during the 1987–1991 special expertise.

### ***1.2. Managing the Activities on Elimination of Accident Consequences***

In compliance with the practice existing at that time, the governmental commission headed by Deputy Chairman of the USSR Council of Ministers B.E.Scherbina was organized on 26 April and arrived at the place of tragedy on the same day. The commission involved A.I.Maiorets, the USSR Energy/Electrification Minister, A.G.Meshkov, First Deputy Minister of the USSR Middle Engineering, and other high rank representatives from the ministries and agencies. The USSR Academy of Sciences was represented by academician V.A.Legasov and the USSR Ministry of Health – by First Deputy Minister A.I.Vorobiev. Directly at the place, the commission was managed in turn by Deputies Chairman of the USSR Council of Ministers I.S.Silaev, L.A.Voronin, Y.D.Masliukov, V.K.Gusev, and G.G.Vedernikov. By autumn 1986, the governmental commission for investigation of the reasons of the Chernobyl accident was transformed into the governmental commission for elimination of its consequences. The latter involved heads of the ministries of health/ agriculture/ hydrometeorological service and those of republican authorities. The republican and local bodies to manage the activities on the issue were established.

In 1989, the USSR Council of Ministers' State Commission for Emergencies was set up in the USSR. It was headed by Deputy Chairman of the USSR Council of Ministers V.Kh.Doguzhiev who was also at the head of the governmental commission for elimination of the Chernobyl accident consequences. In July 1989, the Committee of the same name entered the State Commission. V.A.Gubanov managed the Committee from the moment of its creation till the USSR's collapse. At the same time, the process of forming the republican authorities was under way. In autumn 1990, a decision was made as to the establishment of the RSFSR State Committee for elimination of the Chernobyl accident consequences.

It should be noted that the above authorities within the governmental structure were not always free in their actions. In accordance with the traditions existing at that time in the USSR, it was the Communist party that played the decisive role in making vital decisions. Proceeding from the political significance of the forthcoming activities on elimination of the accident consequences as well as from the specific situation dealt with radioactive contamination, it was solved to concentrate all control levers in the hands of political management of the country. On April 29, 1986, the Operative Group of the CK CPSU Politbureau headed by Chairman of the USSR Council of Ministers N.I.Ryzhkov started its work. To effectively manage the entire complex of activities at sites, the republican commissions, the regional headquarters, the headquarters of ministries/ agencies/ military formations, the operative groups of the Ministry of Defence, and those of head of chemical troops and civil defence were formed. The Inter-Agency Coordination Council for Chernobyl issues presided over by President of the USSR Academy of Sciences A.P.Alexandrov, special working groups and research centers were established to scientifically justify the decisions made, to evaluate and analyse the situation.

### ***1.3. Measures for Public and Environmental Protection***

Since the very first minutes or hours following the accident, urgent and nonordinary measures were required, including those that could not be tackled at the local level. Only due to timely arrival of the Governmental commission to the site and its evaluation of the

radiation status as extraordinary, the vital decisions on public protection, such as to evacuate the residents from the Pripjatj city and afterwards from all the localities within the 30-km zone, were timely made. The item of medical assistance to sufferers from the accident was also effectively solved as all the people most suffered were delivered to the Moscow specialized clinic in less than two days.

Regardless of the actions taken [5], radioactive releases from the destructed reactor continued till May 9. The scale and acuteness of the issues in the site of the Chernobyl NPP contributed to a certain extent to the fact that the main activity on the elimination of radiation consequences was concentrated first in the vicinity of the NPP, and the matters with assessment of the status for the entire country stood somewhat worse. The Governmental commission was concentrated on the issues of the emergency power unit, those of the 30-km zone, construction of the Shelter, and the launches of 1-3 power units. None of the timely instructions on protective measures for the areas remote from the Chernobyl NPP was given by the central authorities. Without such directives, the local authorities could not make radical decisions. As a result, urgent scale actions extremely vital for thyroid protection from radioactive iodine (such as iodine prophylaxis and restricted consumption of contaminated foodstuffs) were deployed with considerable delay. That stipulated their extremely low efficiency and resulted in increased thyroid exposure among considerable public segments, first, among children.

Other errors should also be mentioned. The high management set practically unattainable goals for quickest decontamination of contaminated areas within the 30-km zone. To achieve those aims, it was decided [4] to involve an unprecedentedly great number of people, including those subject to call-up from the reserve. Performance of the large-scale activities within the 30-km zone entailed not only ineffective expenditures, not only certain negative environmental effects [1] but also unjustified participation of an excessive number of liquidators who afterwards faced long-term medical and social consequences.

To involve people for the accident elimination, the USSR Ministry of health approved the 25 Rem value for the dose limit. Radiation damages are not observed below this limit and remote exposure effects eventual from the standpoint of the linear non-threshold concept are not revealed in practice. At the same time, not always a precise dosimetry control was arranged and often the situation developed so that the limit could increase meaningfully.

The gravity of the radiation status in remote areas for the first months following the accident remained without proper attention. It is notable that prior to August 1986 the documents of top management did not mention radioactive contamination of the Russian Federation's lands. Only in September 1986, the USSR Council of Ministers adopted the Decree No. 390-24 (September 04, 1986) [4] on extra evacuation from a number of localities among which the settlements of the Krasnogorsk district of the Bryansk region were first mentioned. The same Decree introduced the limits for consumption of local agricultural production in the Novozybkov, Gordeev and Klintsovsk districts of the Bryansk region.

The lack in the world practice of similar accidents both by their severity and by the scale of radioactive contamination of the areas and by the number of involved people required huge efforts of intellectual and material forces of the country. The centers for scientific support of the activities on elimination of the accident consequences were set up on the base of Roshydromet's inter-agency commission, the Kurchatov Institute, the Biophysics Institute, the Applied Geophysics Institute (Moscow), the Research Radiation Hygiene Institute

ЦЕНТРАЛЬНЫЙ КОМИТЕТ КПСС И СОВЕТ МИНИСТРОВ СССР

ПОСТАНОВЛЕНИЕ

от 29 мая 1986 г. № 634-188

Москва, Кремль

О ПРОВЕДЕНИИ ДЕЗАКТИВАЦИОННЫХ РАБОТ В РАЙОНАХ  
УКРАИНСКОЙ ССР И БЕЛОРУССКОЙ ССР, ПОДВЕРГШИХСЯ  
РАДИОАКТИВНОМУ ЗАГРЯЗНЕНИЮ В СВЯЗИ С АВАРИЕЙ  
НА ЧЕРНОБЫЛЬСКОЙ АЭС

В целях ускорения дезактивационных работ в зоне Чернобыльской АЭС, проведение которых является первоочередной задачей и имеет важное социально-экономическое и политическое значение, Центральный Комитет КПСС и Совет Министров СССР постановляют:

1. Согласиться с разработанным Министерством обороны, Министерством энергетики и электрификации СССР и Министерством среднего машиностроения с участием других министерств и ведомств графиком выполнения работ по дезактивации территорий, зданий и сооружений в зонах с повышенными уровнями радиоактивных загрязнений (прилагается).

2. Обязать Министерство обороны резко усилить работы по дезактивации, обратив особое внимание на первоочередную необходимость борьбы с пылью, строгое соблюдение порядка и последовательности проведения этих работ с учетом уровней радиоактивного загрязнения и прогнозов по его естественному уменьшению. По каждому из участков, подлежащих дезактивации, разработать до 5 июня 1986 г. план проведения дезактивационных работ с учетом специфики указанных участков.

Учитывая большие масштабы дезактивационных работ, ускорить развертывание соответствующих соединений, частей и подразделений, призвать из запаса на специальные учебные сборы сроком до 6 месяцев необходимое количество военнообязанных, а также привлечь из народного хозяйства в установленном порядке транспортные средства и другую технику на период выполнения работ. Призыв военнообязанных осуществлять сверх лимитов, установленных Министерству обороны постановлением Совета Министров СССР от 20 августа 1985 г. № 795-236.

3. Отметить низкую эффективность проводимых в настоящее время дезактивационных работ и недостаточное участие научных учреждений в разработке новых средств дезактивации.

Возложить на Министерство среднего машиностроения, Министерство обороны и Академию наук СССР научно-техническое руководство в решении вопросов выбора и применения эффективных химических реагентов и технических средств дезактивации, способов сбора, захоронения и переработки радиоактивных продуктов и отходов, закрепления, полной локализации или удаления радиоактивных загрязнений из земли, дорог, машинах, оборудовании, зданиях и сооружениях.

4. Центральный Комитет КПСС и Совет Министров СССР обращают особое внимание на недопустимость сложившегося положения, когда из-за неорганизованности, отсутствия должного порядка на отдельных участках работники и военнослужащие подвергаются излишнему облучению.

Штабу гражданской обороны СССР, Совету Министров Украинской ССР, Совету Министров Белорусской ССР, Министерству внутренних дел СССР, Министерству среднего машиностроения и Министерству энергетики и электрификации СССР:

немедленно обеспечить всех работающих в зоне Чернобыльской АЭС индивидуальными дозиметрами, респираторами, противогазами и другими защитными средствами, организовать строгий учет уровня облучения работающих и своевременную замену лиц, получивших предельную дозу, развернуть необходимое количество санитарно-пропускников, постов дозиметрического контроля, а также специальных пунктов для дезактивации транспортных средств и прачечных для санитарной обработки обмундирования и одежды, создать необходимые запасы указанных защитных средств, обмундирования и одежды. Разрешить в этих целях расконсервацию соответствующих мобилизационных резервов;

принять дополнительные меры к обеспечению безопасности и улучшению обслуживания работающих на территории Чернобыльской АЭС, организовать обучение персонала, занятого на дезактивационных работах, правилам их производства и личной гигиены в условиях высоких уровней радиации;

по мере выполнения в указанной зоне дезактивационных работ и создания безопасных условий для проживания людей устанавливать совместно с Министерством здравоохранения СССР сроки и порядок

(Saint Petersburg), the Medical Radiology Institute, the Agricultural Radiology Institute, SPA "Taifun" (Obninsk) and a number of other scientific organizations. New scientific and practical centers in the field of radiation hygiene, radiation medicine and agricultural radiology also were created in Kiev/ Minsk/Gomel. Within the USSR Academy of Sciences, a new Nuclear Safety Institute (IBRAE RAS at present) was established with the aim of system-analytical and information support for the activities on state Chernobyl programs.

Practical and scientific potential available in the country made it possible to develop and implement in undertime a large-scale complex of protective measures for contaminated ar-

eas. Intensity of protective and remediation measures was defined on the base of area zoning. While the radiation status was specified, the volumes of emergency actions increased. The main activities ran in the first years in the so called zone of strict control restricted by the isoline of 15 Ci/km<sup>2</sup> by Cs-137 (about 100,000 residents). The zone boundary was chosen in 1986, proceeding from the assumption that the 100 mSv dose limit for the first year be not exceeded. Afterwards, the following restrictions were adopted for permissible public exposure doses in contaminated areas: 30 mSv —in the second year and 25 mSv — in the third year. The protective actions under way made it possible to reduce significantly public exposure doses, however, they damaged the lifestyle people were accustomed to.

Characterizing the protective measures implemented within the first years following the accident, it should be acknowledged that except for the above errors, the objectives unprecedented by their complexity were overall solved, namely:

- Annual public exposure dose limits established by the Ministry of health were not exceeded;
- Catastrophic losses in the agricultural area and in the forestry were prevented;
- The social and economic situation in contaminated areas was stabilized to a certain extent.

Meanwhile, the situation was overall accompanied by the two differently directed tendencies. In spite of progressive public exposure dose reduction and provision of environmental safety for the power unit destructed, public negative perception of the accident increased significantly and the assessment of accident consequences began to correlate with the level of national catastrophe.

#### ***1.4. Elaboration of the Strategy of Protective Measures under Conditions of Political Crisis***

Growth of confrontation between the center and the union republics was one of the main peculiarities of political processes in the USSR in the late 1980s.

While the policy of “openness” developed, the measures as to classifying the data as secret became the subject of strict criticism which afterwards extended to include the overall complex of activities on the elimination of accident consequences, including the decisions on the part of the authorities and the recommendations of Soviet scientists. It should be noted that the works of those scientists in the South Urals and during the nuclear tests made it possible to evaluate their scientific and practical experience in the field of radiation medicine, biology, agricultural radiology and ecology as fundamental and as having no world analogues.

The culmination of critical moods became the discussion of “the 35Rem concept” offered by the National commission for radiation protection (NCRP). The 35Rem dose limit in 70 years of life was offered by NCRP as a criterion for decision-making as to eventual remediation of the area within a relatively short term. The conception development was not only associated with the items of public safety. It sooner was the response of scientists to their understanding of fatal consequences of long-term restrictions in living conditions. During the concept elaboration, it was assumed that in the areas where the 35Rem limit was not reached the stage-by-stage return to normal live conditions was possible. In those cases where that limit was exceeded, the options for intensive remediation actions were



considered. Relocation of the residents was supposed only for those settlements where the above actions did not help. Therefore, the concept established quite a strict limit for the dose permissible in 70 years and allowed the experts to define the perspectives more rapidly. For the first time in the world practice, the concept offered to restrict the life exposure (70 years), rather than to limit the annual doses. Such approach not only provided reliable radiation protection for the public but also made it possible to enter the historically visible vistas for the purpose of final solving the problem for every locality instead of the peripeteias associated with the annual dose restriction for extra exposure.

After the concept was adopted by the Government, it was strongly disapproved by the public and the local authorities who thought the relocation to be the sole adequate protective measure. Under pressure of mass criticism, the USSR Government applied to the IAEA with the request to run international expertise of the measures on elimination of radiation consequences and on public protection, including the 35Rem concept offered by domestic scientists. This request demonstrated complete distrust of the authorities in the domestic science.

In response to the USSR Government, the international community initiated the International Chernobyl Project (ICP) implemented in 1989–1990. Almost 300 leading world experts were involved, including those from WHO/ FAO/ IAEA and other international organizations. Within the project scope, not only the decisions made but also the overall status in the contaminated areas was assessed, including the health status of the residents. The first discussions of the strategy of the implemented protective measures showed that the leading foreign scientists considered the USSR NCRP concept too conservative. It was natural that such conclusion was not convenient for the proponents of relocation and the ICP results started to be ignored. By the moment of publication of the final ICP results, the strategic solutions had already been accepted and fixed by the laws.

Basically, it was a compromise agreement as to the fact that the extra exposure doses up to 1 mSv/year did not require special measures and that only the 5 mSv/year doses were the basis for relocation along with even more simplified approaches based on the density of radionuclide soil contamination, rather than on the dose. The 1 Ci/km<sup>2</sup> level was adopted as the lower value for the density of soil contaminated by Cs-137 to be used for correlation with the zones of radioactive contamination. Therefore, the appropriate laws of the union republics and the USSR ignored both the position of domestic scientists and the recommendations of the world science fixed in the ICP conclusions [6].

*“The long-term protective measures accepted or planned, though based on good intentions, go overall beyond the things that were strictly required from the standpoint of radiation protection provision. The measures on relocation or restriction of foodstuffs were to be approved in the lesser scope. These measures were unjustified from the standpoint of radiation protection, though, any mitigation of the current policy could almost certainly entail negative results due to high levels of stress situations and the anxiety of residents with regard to the appropriate contaminated areas, as well as the current expectation of relocation. However, a lot of social and political factors are acknowledged to exist to be taken into account and a final decision should be made by responsible competent bodies. In any case, any introduction should not entail stricter restrictive criteria” — p. 609.*

As for the health effects, the final ICP document covered the following conclusions:

*Significant health damages, though not stipulated by radiation, were revealed among the residents from both investigated contaminated areas and control settlements studied within the scope of the Project. Any health damages directly associated with irradiation effects were not revealed. The accident entailed considerable negative psychological consequences expressed through increased anxiety or stress occurrence due to a constant feeling of quite strong uncertainty observed even outside the appropriate contaminated areas. The consequences were aggravated at the background of social and economic and political changes taking place in the USSR” — p. 605.*

The following forecast as to the eventual remote accident consequences was performed:

*“The represented estimates of absorbed thyroid exposure doses among the children certify to the fact that a statistically defined increase in the frequency of occurrence of thyroid tumours is possible in future.*

*Based on the doses evaluated within the scope of the Project and proceeding from the radiological risk assessments currently approved, it is possible to state that future increase in the number of all cancer diseases or hereditary changes, as compared with the natural level, will be so low that it will be difficult to define it statistically even during large-scale and well-organized long-term epidemiological research” — p. 605.*

By the ICP expert opinion, decrease in the number of relocated settlements is a blessing, as relocation is a severe human trial and the health risk from this action is much higher than from the doses obtained. The situation is similar with other protective measures. The ICRP recommendations say that “...the annual exposure dose reaching the 10 mSv value can be used as a control level below which the intervention in some situations dealt with prolonged exposure can hardly be considered as justified” [Cited by 7].

By the early 1990s, the three republics planned in practice to relocate additionally many tens of thousands of residents. Only in the Russian Federation, the number of regions believed to be contaminated increased from 4 to 17 and the number of suffered population grew from 0.2 to 2.6 million people.

Since 1991, the governing document on social protection of citizens and economic remediation of the areas affected by the Chernobyl accident became the May 15, 1991 RF Law “On Social Protection of the Citizens Affected by Radiation Resulted at the Chernobyl NPP” which was supplemented and amended. As was mentioned above, the similar laws were approved in Byelorussia and the Ukraine.

By the fifth anniversary of the accident, quite a contradictory situation had devel-



oped. The radiation status made it possible to concentrate protective actions in the fairly limited areas. At the same time, the supreme authorities of the USSR made unprecedented decisions that initiated mass relocation, construction of thousands of new sites, development of new research with regard to the items well known to the experts. The most severe by its potential negative consequences was the decision on involvement of millions of residents from poorly contaminated areas into the post-accident situation.

The collapse of the USSR that followed has created a situation where the liabilities taken in respect of the public affected by the accident turned out to be in principle unrealizable to the full extent. As a result of heavy economic crisis which involved new countries, the volume of practically implemented actions turned to be even less. That somewhat mitigated the negative consequences of the decisions on mass relocation, etc. For instance, none of the major localities was relocated in the Russian Federation. Even the most contaminated settlements failed to be relocated.

### ***1.5. Creation of System to Manage Activities on Elimination of Chernobyl Consequences in Russian Federation***

The RSFSR State Committee set up in 1990 for elimination of the Chernobyl accident consequences was headed by S.S.Voloschuk. The Committee was to perform its activity in Bryansk. Independent practical work of GosComChernobyl started after the USSR's collapse. In summer 1992, it was V.Y.Voznyak who headed the Committee, and by the end of the year the Russia's Government approved the first State program for mitigating the Chernobyl consequences. In the early 1994, GosComChernobyl's functions were transferred to EMERCOM of Russia where the above items were supervised in turn by V.A.Vladimirov, S.V.Khetagurov and N.V.Gerasimova, Deputies Minister.

Overall, the system for elimination of the Chernobyl accident consequences formed on the base of the general system of federal executive authorities and the actual content of those or other aspects of activity.

At present, EMERCOM of Russia performs the functions of a developer and a state customer who is the coordinator of activities on elimination of radiological emergencies.

The huge amount of work is effected by the following ministries/agencies:

- Russia's Ministry of Health and Social Development covers the items of social protection and rendering general medical assistance to the individuals affected by the accident;
- Roshydromet is liable for control of the radiation status on the territory of the Russian Federation;
- Russia's Ministry of Agriculture supervises the remediation and protective actions in agricultural complex on radio-contaminated lands, as well as performs control over radioactive contamination in agricultural regions, over production of plant cultivation and cattle breeding;
- Russia's Ministry of Natural Resources is liable for the items of radioactive contamination of forest resources and for special forest-protection and forestry actions in the areas of radioactive contamination.

## 2. RADIOECOLOGICAL ACCIDENT CONSEQUENCES

The accident at the Chernobyl NPP has entailed major radioactive releases into the environment and long-term contamination of vast areas. By the mid of May, 1986, owing to the analysis of available data and the scientific and practical experience gained prior to the accident, it became clear that one should not expect scale negative effects for the objects of wildlife at the available levels of radioactive contamination in the Russian Federation's areas. Also it was clear that radioactive contamination would require scale measures for public protection especially during the acute period, as well as long-term protective and rehabilitation measures with respect to contaminated agricultural lands and forests.

### *2.1. Zones of Radioactive Contamination in Russian Federation*

Intensive radioactive releases from the destroyed reactor went on from April 26 through May 9, 1986. That stipulated a complex configuration of radioactive traces in the site characterized by a peculiar radionuclide structure and their physical and chemical form. That and also large contaminated areas and local peculiarities of the fall-outs predetermined a need for the simulation/ reconstruction methods to be used to estimate environmental contamination by short-lived radionuclides, including iodine radionuclides. As for long-lived radionuclides, the situation was quite different in principal: the contamination assessment ran basically by the data of measurements. An unprecedented great volume of actual data was accumulated and analysed.

After the accident, the two forms of Chernobyl fall-outs were distinguished: fuel particles and gaseous condensate precipitations comprising fine aerosols. The fall-outs of fuel particles occurred mainly in the nearest 30-km zone of the ChNPP, owing to which plutonium radionuclides turned to be concentrated in the nearest zone and did not much impact the public outside it from the radiological standpoint. The main part of precipitations with a significant strontium contribution also was concentrated in the immediate proximity to the ChNPP.

In the long-term plan, the basic dose-forming radionuclide in a greater part of the Chernobyl trail, including in the Russian Federation, was Cs-137 (the 30-year half-life period). The total Cs-137 release was estimated as  $8 \cdot 10^{16}$  Bq; including 30 % on Russia's territory.

In the first years following the accident, main attention was given to specify the radiation status on the most contaminated lands where the Cs-137 density was above  $5 \text{ Ci/km}^2$ . In 1991–1992, due to approval of the USSR/RSFSR appropriate laws, specifying was conducted with respect to the lists of localities suffered from radioactive contamination with density of  $1 \text{ Ci/km}^2$  or higher. By 1993–1995, the experts had succeeded in solving an extremely complicated challenge of creating the atlas of radioactive contamination in the European part of the Russian Federation [1] and that of radioactive caesium contamination in Europe [2].

The sites with the Cs-137 contamination level of soil higher than  $1 \text{ Ci/km}^2$  ( $37 \text{ kBq/m}^2$ ) were revealed on the territory of 19 Russian regions; their total area amounting to 59.3 thous.  $\text{km}^2$ . The most contaminated areas are the regions of Bryansk (11.8 thous.  $\text{km}^2$  of contaminated areas), Kaluga (4.9 thous.  $\text{km}^2$ ), Tula (11.6 thous.  $\text{km}^2$ ) and Oryol

(8.9 thous. km<sup>2</sup>). The lands with the density of contamination above 15 Ci/km<sup>2</sup> (555 kBq/m<sup>2</sup>) exist only in the Bryansk region.

It should be noted that the areas of many states were affected by radioactive contamination. In Northern hemisphere, about 60 thous. km<sup>2</sup> out of 200 thous. km<sup>2</sup> contaminated by radioactive caesium with the density exceeding 1 Ci/km<sup>2</sup> (37 kBq/m<sup>2</sup>) are outside the former USSR.

Table 2.1

**Cumulative Contamination of European Countries by <sup>137</sup>Cs As a Result of Chernobyl Accident [2]**

Country	Area, 10 <sup>3</sup> km <sup>2</sup>		Chernobyl Fall-outs		
	State	Areas Contaminated above 1 Ci/km <sup>2</sup>	PBq	kCi	% from Cumulative Fall-Outs in Europe
Austria	84	11.08	1.6	42.0	2.4
<b>Byelorussia</b>	<b>210</b>	<b>43.50</b>	<b>15.0</b>	<b>400.0</b>	<b>23.4</b>
Great Britain	240	0.16	0.53	14.0	0.83
Germany	350	0.32	1.2	32.0	1.8
Greece	130	1.24	0.69	19.0	1.1
Italy	280	1.35	0.57	15.0	0.9
Norway	320	7.18	2.0	53.0	3.1
Poland	310	0.52	0.4	11.0	0.63
<b>Russia (European Part)</b>	<b>3 800</b>	<b>59.30</b>	<b>19.0</b>	<b>520.0</b>	<b>29.7</b>
Romania	240	1.20	1.5	41.0	2.4
Slovakia	49	0.02	0.18	4.7	0.28
Slovenia	20	0.61	0.33	8.9	0.52
<b>Ukraine</b>	<b>600</b>	<b>37.63</b>	<b>12.0</b>	<b>310.0</b>	<b>18.8</b>
Finland	340	19.00	3.1	83.0	4.8
Czechia	79	0.21	0.34	9.3	0.54
Switzerland	41	0.73	0.27	7.3	0.43
Sweden	450	23.44	2.9	79.0	4.6
<b>Overall Europe</b>	<b>9 700</b>	<b>207.5</b>	<b>64.0</b>	<b>1700.0</b>	<b>100.0</b>
<b>Entire World</b>			<b>77.0</b>	<b>2100.0</b>	

The multi-year research has shown that the nature of change in the radiation status of the Russian Federation's territory is predictable and stable: all mechanisms under observation are close to those described [3].

As in the other regions, a change in the radiological conditions is mainly impacted by the following:

- Natural radionuclide decay;
- Radionuclide deepening under conditions of natural climatic processes;
- Radionuclide fixation in geochemical and soil structures;
- Radionuclide re-distribution in a soil layer due to the human-induced impact.

In the first years, extremely great importance was given to a hazard of radioactive discharges into reservoirs from the areas contaminated. However even in 1987, discharges from the area of water collectors did not exceed 1 % from the total stock of activity. Therefore, radioactive contamination of surface waters on the Russian Federation's territory does not represent any problem for all reservoirs, except for the Kozhanovsk and the Saint closed lakes located in the South-West of the Bryansk region. These lakes which bottom comprises underlying peat soils are characterized by the limited ability to fix Cs-137. As a result, the Cs-137 concentrations in the water and the fish living in these reservoirs exceed the admissible levels (for instance, the Cs-137 content in the fish in the Kozhanovsk lake has recently reached 5–7 kBq/kg for crucians and 20 kBq/kg — for pikes).

Horizontal radionuclide migration also is rather low: in most cases, it does not lead to radionuclide transfer measured between the landscape complexes. To estimate the intensity of these processes, the reservoir method is used at which the research is dedicated to small water collectors where the interfaces typical of the given landscapes are considered. The research has shown that within two decades following the accident, the field of Cs-137 contamination underwent changes of purely local nature under the impact of landscape processes. Self-purification of the area due to decay is supported by the processes of radioactive caesium penetration deep into soils, by horizontal transfer of caesium retained in soil particles, and by its alienation with a crop. Under these conditions, the rates of decrease in the levels of radioactive contamination of soils make up slightly more than 3 % a year. Despite of the low rates of decrease in the levels of caesium content in the soil, the radiation status in the contaminated areas changes more rapidly both by the parameters of dose rate and by the indices of radionuclide content in agricultural production.

The radioecological status of the contaminated areas is a subject of detailed research/discussions at important scientific forums [4].

As was mentioned above, main attention even in the initial milestone of activities was paid to the zone of strict control limited by the isoline of 15 Ci/km<sup>2</sup>. As the radiation status was specified, the zone of activities enlarged and the nature of actions was clarified and improved. During the transfer to a restoration phase of the elimination of accident consequences, new approaches to restrict public exposure and zoning of the areas were offered.

In the early 1991, the Soviet Government approved the concept for residence in the contaminated areas. It established a new intervention level which was extra exposure in the doze above 1 mSv/year. The new dose criterion also was offered for zoning of the areas; however, the old criterion, such as the density of soil contamination by caesium, preserved. According to the 1991 RF Law «On Social Protection of Citizens Suffered from Radiation as a Result of Chernobyl Catastrophe», zoning of the areas was performed by a degree of contamination and the dose criterion was not actually used.

In particular, the Law established the following zones of radioactive contamination:

- Exclusion zone covers the areas which population was evacuated in 1986 and in the years that followed;
- Resettlement zone comprises the areas which density of Cs-137 contamination exceeds 15 Ci/km<sup>2</sup>. The population of this zone is subject to obligatory resettlement (a zone of obligatory resettlement) in the districts where the contamination density exceeds 40 Ci/km<sup>2</sup> or the average annual effective doze (AAED) may exceed 5 mSv;

- Zone of residence with the right for relocation covers the areas of Cs-137 contamination density of 5–15 Ci/km<sup>2</sup> or the AAED above 1 mSv;
- Zone of preferential social and economic status covers the areas of Cs-137 contamination density of 1 to 5 Ci/km<sup>2</sup> where the AAED does not exceed 1 mSv.

In 1995, the Russian Scientific Commission for Radiation Protection (RSCRП) developed a «Concept for Radiation, Medical, Social Protection and Rehabilitation of the Russian Federation's Population Affected by Emergency Exposure». The concept was approved by the Government and envisaged that zoning of the contaminated areas should be performed solely by the dose principle. For the areas of resettlements where the AAED did not exceed 1 mSv, residence of people and public economic activities were assumed to be unrestricted by the radiation factor. In spite of considerable efforts, the transfer to the dose conception has not been performed up to now.

The current status of zoning is defined by the RF Governmental Decree dt. December 18, 1997 «On Adoption of List of Localities Being within Boundaries of Zones of Radioactive Contamination as a Result of Chernobyl Catastrophe» (Table 2.2). It should be noted that the list significantly reduced the number of localities covered by the zones of radioactive contamination, mainly due to stricter adherence to the criterion of contamination density. However, observation of that simplified principle of relating the localities to the contamination zones provoked a great number of conflict situations associated with repayment of benefits and compensations. A rather conditional and in principle regulated criterion became the subject of hearings related with exclusion and return of the localities to the zones of radioactive contamination. In compliance with the court decisions, the RF Governmental Decree No.197 dt. April 7, 2005 amended and supplemented the valid list of localities. The status of a radio-contaminated zone was changed towards toughening for 64 localities and 70 additional settlements entered the list. As of January 1, 2006, in total 4413 localities relate to the zones of radioactive contamination.

On-going control of the radiation status is performed by the following parameters:

- Radioactive environmental contamination (atmospheric air/soil/ surface wates);
- Radiation and hygienic monitoring;
- Contamination of agricultural lands/ production; and
- Control over production of forestry.

It is possible to conclude by the results of monitoring that as of today the radiation status has stabilized in the areas contaminated as a result of the Chernobyl accident. Practically everywhere, the exposure dose rate of gamma rays in sites makes up 10-20 µR/hour, except for the most contaminated areas.

Control of the long-lived radionuclide content in the foodstuffs certifies to the fact that excess standards are revealed only in some districts of the Bryansk and Kaluga regions. In particular, 902 (5 %) out of 17,674 investigated samples in the Bryansk region and 48 out of 6,453 (less than 1 %) in the Kaluga region did not correspond to SANPIN during 2002–2004.

As compared with the initial post-accident period, the radiation levels have decreased by hundreds times owing to natural processes of self-purification and due to the protective actions performed. At present, radiation relates neither to the number of significant risk factors for public health nor to the basic source of exposure. The structure of public expo-

sure doses for the contaminated areas slightly differs from the all-Russian one. Natural radiation sources contribute most to public exposure and medical procedures do approximately twice less. Even in the Bryansk region, the share of the Chernobyl accident makes up about 10 % of the cumulative doze. However, the Chernobyl additive in the most contaminated areas is comparable with the natural background or may even slightly exceed it.

Table 2.2

**Allocation of the Public by Zones of Radioactive Contamination (thous. people)**

RF Subject	Zones of Radioactive Contamination by the RF Governmental Decree dt. December 28, 1991 (taking into account the RF Governmental Decrees of 1993–1995)			Zones of Radioactive Contamination by the RF Governmental Decree No. 1582dt. December 18, 1997		
	Preferential Social and Economic Status	Residence with the right to relocation	Resettlement	Preferential Social and Economic Status	Residence with the right to relocation	Resettlement
Bryansk Region	239.6	151.8	90.5	163.1	136.2	80.9
Kaluga Region	88.5	16.7		88.4	5.2	
Oryol Region	338.6	16.7		128.2	16.4	
Tula Region	797.1	139.5		719.4	32.5	
Belgorod Region	77.1			75.6		
Voronezh Region	40.4			32.8		
Kursk Region	138.9			124.8		
Leningrad Region	19.6			8.4		
Lipetsk Region	70.6			35.6		
Mordovia Republic	17.9			10.9		
Penza Region	130.4			9.7		
Riazan Region	199.6			122.5		
Tambov Region	16.6			2.0		
Ulianov Region	58.0			2.8		
<b>TOTAL</b>	<b>2 232.9</b>	<b>324.7</b>	<b>90.5</b>	<b>1 524.1</b>	<b>190.3</b>	<b>80.9</b>
<b>Cumulative TOTAL for the public:</b>	<b>2 648.1</b>			<b>1 795.3</b>		

**2.2. Modified Conditions for Public Life Activity**

In accordance with the predictions, radioactive contamination of the RF territory has not entailed any serious changes in the status of the objects of wildlife. Nevertheless, numerous restrictions introduced by the authorities have fundamentally affected the public lifestyle, especially in those rural settlements where the restrictions covered a lot of kinds of traditional activity, such as fishing and hunting, storage of mushrooms and berries, farming, etc. In many cases, the restrictions were introduced for different kinds of economic activity, including agriculture and forestry. Apart from it, varied self-restriction was ob-



served in the contaminated areas: people appeared less in the open air and limited their consumption of local foodstuffs, etc.

Cardinal change in the life activity has occurred in the exclusion zone. According to the law, *«permanent public residence is forbidden in the exclusion zone of the Russian Federation's area; the economic activity and nature management are limited»*, and the list of permitted kinds of activity is established by the RF Government [14]. Among other things, the following is prohibited in the exclusion zone:

- «All kinds of forest utilisation; stocking of hay/ wild-growing fruits/ berries/ mushrooms/ crude drug and technological raw material; hunting, and fishing;
- Driving/pasture of domestic animals;
- Extraction and processing of all kinds of minerals;
- Running any kinds of activities dealt with the damage of top-soil without special sanction on the part of local authorities from the RF Ministry of environmental protection and natural resources as well as local administration».

In accordance with the RF Governmental Decree No. 1582 dt. December 18, 1997 «On Adoption of List of Localities Being within Boundaries of Zones of Radioactive Contamination as a Result of Chernobyl Catastrophe», 4 settlements from the Krasnogorsk district of the Bryansk region are related to the exclusion zone. Its boundaries are defined by the Federal Geodesy/Cartography Agency: it is a 500-meter zone around the former settlements (Fig. 2.1).

Serious restrictions in economic activity are approved for the resettlement zone as well [14]: «the economic activity is authorized by local administration by the results of the radioecology control».

For a zone of residence with the right to resettlement, the restrictions are much milder: «the use of plots according to their destination is performed in compliance with the recommendations of...».

When characterizing the impact of accident consequences on the modified conditions of public life activity, it bears emphasis that the sanitary restrictions dealt with impossibility to use or realize the contaminated foodstuffs have negative effects in no lesser extent than direct regulations and restrictions on certain kinds of economic activity.

### ***2.3. Agricultural Consequences***

In the Russian Federation, almost 2 million of hectares of agricultural lands (Table 2.3) suffered from radioactive contamination. In some areas, the contamination levels were so high that the use of agricultural production on them became impossible (for instance, part of South-West districts of the Bryansk region).

The problem of running agricultural production and that of providing the public with the products corresponding to the sanitary-and-hygienic standards has turned out to be the challenge. The high levels of contamination of agricultural lands stipulated the need for protective actions in all branches of agriculture, as well as for use of special technologies, when processing agricultural raw materials. The areas with developed agriculture were mostly affected by contamination. They produced from 40% to 70% of grain, up to 60% of

potatoes and from 30% to 60% of cattle-breeding production of the total production in these areas (Table 2.4).



Fig. 2.1. The boundaries of the exclusion zone in the Russian Federation around the settlements Barsuki (a), Kniazevschina (b), N. Melnitsa (c), and Progress (d)

Table 2.3.

**Distribution of Agricultural Territories With Respect to  $^{137}\text{Cs}$  Contamination Density (ha) [13]**

Region	$^{137}\text{Cs}$ , Contamination Density, kBq/m <sup>2</sup>				Total
	37–185	185–555	555–1480	>1480	
Bryansk	401 400	186 600	97 600	17 106	702 706
Kaluga	111 700	33 100	700	–	145 500
Oryol	396 400	22 800	–	–	419 200
Tula	653 000	125 700	–	–	778 700

Table 2.4.

**Agricultural Production on RF Territory Affected by Contamination  
as a Result of Chernobyl Accident, thous. t (1986)**

Region	Grain	Potatoes	Vegetables	Milk	Meat
Bryansk	296.6	691.4	46.9	57.6	14.4
Kaluga	38.5	50.5	0.04	49.6	8.2
Oryol	370.4	177.5	17.8	450	106.7
Tula	1437	327	51	670	195
Total	2142.5	1246.4	115.74	1227.2	324.3

The important features of the basic zone of contamination have become peculiar soil conditions. Poor soils with low sorption ability and, as a result, with the increased intensity of radionuclide migration, such as  $^{90}\text{Sr}$  и  $^{137}\text{Cs}$ , in trophic agricultural chains prevail in the most contaminated areas of marshy woodlands.

The accident has set before agricultural radioecology a number of new objectives which, overall, have been successfully solved and realized in the developed methods for plant cultivation and cattle breeding. The methods take into account soil properties, biological peculiarities of plants and animals, peculiarities of agricultural practice, including the intensity of protective measures.

Owing to large-scale performance of the land treatment actions (radical and superficial improvement of haymakings and pastures) and due to introduction of organizational actions in the areas with the highest levels of contamination (Novozybkov/ Krasnogorsk/ Gordeev districts of the Bryansk region), it became possible to reduce greatly the caesium concentration in milk in the first two-three years. In the contaminated areas of the Kaluga region where the protective actions were of limited scale, the reduction of Cs-137 content in milk happened to be much slower (Fig. 2.2) [14–18].

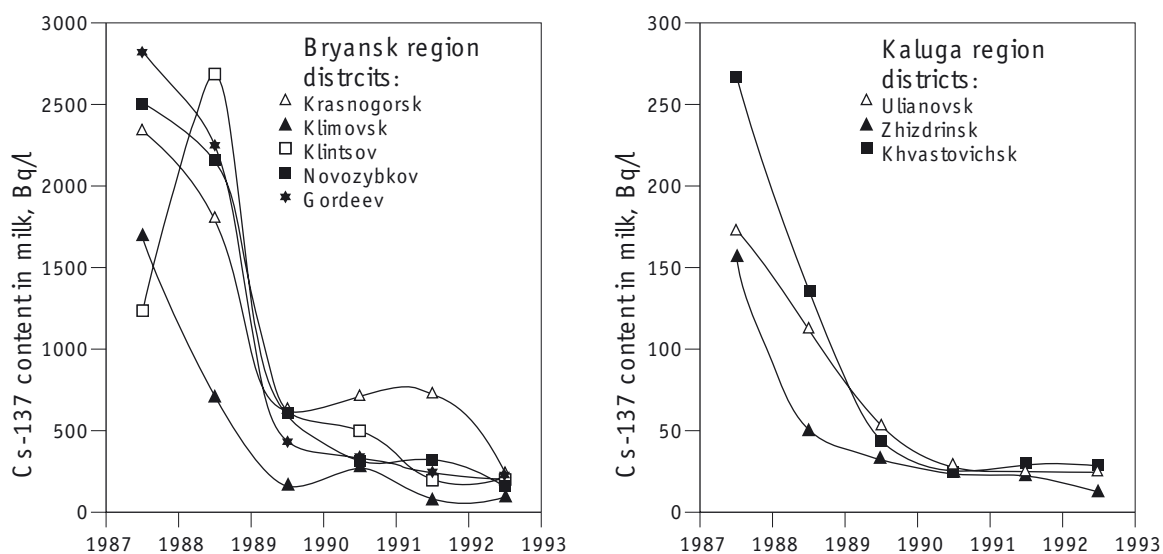


Fig. 2.2. Dynamics for  $^{137}\text{Cs}$  Content in Milk in the Areas of Russia Affected by Radioactive Contamination as a Result of the Chernobyl Accident

The quickest reduction of Cs-137 concentration in milk, as well as in other kinds of agricultural production, was revealed in the first year following the accident. The average values of the index during 1987–1989 have decreased more than by 4 times in the Krasnogorsk/ Gordeev/ Klintsov districts of the Bryansk region and more than by 7 times in the Novozybkov district of the same region [16]. In the subsequent period, the reduction of Cs-137 concentration in milk was slower (on average by 2–3 times during 1989–1992) (Table 2.5).

Table 2.5.

**Ecological periods of <sup>137</sup>Cs half-decrease in milk, years**

Districts	Mid Period (1987–1994), $T_e^1$	First Period (1987–1989), $T_e^1$	Second Period (1990–1995), $T_e^2$
Bryansk Region			
Gordeev	1,7	1,2	2,6
Klimov	1,8	–	4,7
Klintsov	2,3	1,3	2,6
Krasnogorsk	1,8	1,0	3,5
Novozybkov	1,6	0,8	4,2
Kaluga Region			
Khvastovichsk	2,3	1,5	6,3
Uljanovsk	4,8	1,8	11,7
Zhizdrinsk	2,9	1,1	5,7

Similar laws are typical of Cs-137 concentration decrease in the production of plant cultivation. In most cases, the values of half-decrease time for its basic kinds are higher than for milk and make up the  $T_e^1$  — from 0.6 to 1.7 years and the  $T_e^2$  — from 1.7 to 14 years [18] for the districts of the Bryansk region.

For the districts of the Kaluga region, the  $T_{e1}$  ranges from 1.0 to 2.9 years and the  $T_{e2}$  — from 3 to 14 and more years. Therefore, the time of Cs-137 half-decrease for all kinds of plant cultivation in the districts of the Bryansk region is significantly less (1.0–2.8 years) than in those of the Kaluga region (2.0–6.9 years). This fact correlates with a great volume of protective actions run in the Bryansk region, as well as with their earlier start-up after the accident.

Since 1995, the rates of Cs-137 decrease in agricultural production became even more slower; apart from it, the dynamics for this decrease strongly varied in the districts with different volumes of protective actions run in 1990–1992. In the districts with the most intensive implementation of counter-measures, the tendency for increase in production contamination was observed after their termination in 1995–1999. In the districts with limited use of protective actions, increase in the levels of production contamination was compensated by natural reduction of Cs-137 in the soil, its radionuclide content in products being approximately of the same level [19].

The elimination of radiation consequences caused the need to solve fundamental scientific problems on investigation of radionuclide behaviour in agricultural ecosystems; development/implementation of the radiation control systems for production and those to monitor

the radiation status; justification/development of quite new methods and ways to remediate contaminated areas for sustainable development of agriculture and safe public residence.

At present, the technologies developed to run agriculture under conditions of radioactive contamination are used restrictedly. Among the reasons, it is not only their impact on the cost value of production but also the overall status of agriculture in the regions under consideration. Nevertheless, the need in implementation of protective measures in agricultural sector of the most contaminated regions is of no doubt.

## 2.4. Forestry Consequences

In the Russian Federation, more than 1.5 million ha of forests (Table 2.6) were affected by radioactive contamination. The caesium contamination density exceeded 1480 kBq/m<sup>2</sup> (40 Ci/km<sup>2</sup>) in the area of 2 thousand ha. The nature of forest contamination and of the processes that followed was not peculiar, as compared to the patterns described in the material [11]. Radioactive contamination covered the areas of coniferous, mixed coniferous-broad-leaved forests, broad-leaved forests, and forest-steppes. A variety of forest-and-plant conditions and biomorphological peculiarities of forest phytocenoses stipulates for considerable distinctions in their ecological and economic value, as well as in the arrangements for the system of protective measures under conditions of radioactive contamination.

Table 2.6.

**Area of forest resources (supervised by MNR of Russia) contaminated by <sup>137</sup>Cs as a result of Chernobyl accident and forecast for change in forestry areas covered by radionuclide Contamination for the period up to 2046. thous. ha**

RF Subjects	Contaminated Forest Resources. thous. ha. by Density of Soil Contamination by Cs-137. Ci/km <sup>2</sup>											
	1-5			5-15			15-40			Above 40		
	1997	2016	2046	1997	2016	2046	1997	2016	2046	1997	2016	2046
<b>Regions</b>												
Bryansk	103.10	89.24	91.25	39.70	36.11	26.14	26.00	18.12	1.54	2.20	1.76	0.52
Kaluga	132.60	112.59	110.10	43.80	31.11	1.40	1.40	0.95				
Tula	66.00	52.92	44.40	11.40	8.01	0.10	0.10	0.07				
Oryol	95.60	72.15	49.30	1.50	1.05							
Riazan	70.20	52.68	35.20	0.10	0.07							
Penza	148.40	111.30	74.20									
Leningrad	85.70	64.28	42.85									
Uljanovsk	69.40	52.05	34.70									
Voronezh	25.30	18.98	12.65									
Kursk	21.30	15.98	10.65									
Belgorod	15.40	11.55	7.70									
Lipetsk	15.40	11.55	7.70									
Smolensk	5.00	3.75	2.50									
Tambov	1.70	1.28	0.85									
<b>Republics</b>												
Mordovia	1.30	0.98	0.65									
<b>Total</b>	<b>856.40</b>	<b>671.25</b>	<b>524.70</b>	<b>96.50</b>	<b>76.35</b>	<b>27.64</b>	<b>27.50</b>	<b>19.14</b>	<b>1.54</b>	<b>2.20</b>	<b>1.76</b>	<b>0.52</b>

101 timber enterprise and 321 forest areas are available on the contaminated territory; above 50 thousand forestry employees and members of their families reside and work in

the area. The most contaminated are forest resources of the Bryansk/ Kaluga/ Ryazan/ Oryol/ Tula regions. Radiation effects have changed social and economic value of the forest, has violated the accustomed regime of running the forestry, and has created a number of restrictions in forestry activity and multi-purpose forest utilization.

Forests include released radionuclides in biological circulation of substances preventing their migration to other areas. Self-purification of forest ecosystems from radionuclides that enter wood or other plants by a root way occurs mainly in the process of natural radioactive decay; therefore, the forests contaminated by radionuclides remain such for many decades (Table 2.6). Public exposure may take place both from wood (external) and from consumption of mushrooms and berries (internal).

In the Russian Federation, the radiation monitoring system for forests and control of radionuclide content in forest resources is arranged. Regional forest production laboratories enter the unified radiation control system (RCS). The all-Russian Research Institute of Forestry and Forestry Mechanization (RRIFM) of Russia's Ministry of Natural Resources (MNR) provides for scientifically-methodical and metrological maintenance of RCS. Recently, radiation monitoring of forests is performed in cooperation with the organizations of Byelorussia.

In 1991–1992, forestry authorities ran the terrestrial quarterly radiation inspection of soils from forest resources of the area of 982,000 ha in 15 RF subjects. During 1988–1996, regional forest production laboratories laid 130 stationary sites designed for long period of observation in 15 RF subjects. Annually, the laboratories of radiation control select and perform radiometric analysis of soil samples, structural parts of wood plants, food forest resources and other components of forest ecosystems at each site. The results of monitoring are used to develop normative and methodical documents and correct the systems of protective actions, when running the forestry in the areas contaminated by radionuclides.

The monitoring data shows that further decrease by 20–40% in the dose rate of ionizing radiation has occurred in the forests in the past decade.

The general tendencies for contamination of forest resources are such that the increase in radionuclide content in wood of the main forest-forming breeds was observed in all regions up to 2000. In the years that followed, some stabilization of Cs-137 in wood forest resources was registered. As a rule, the radionuclide content in the wood of deciduous breeds exceeds by 2 times their content in coniferous ones. In 10–15 years, a transfer to a phase of caesium decrease in the wood is anticipated.

At present, the levels of Cs-137 in the wood may exceed the admissible levels (AL) for dwelling construction (SP 2.6.1.759-99), in the case of radioactive soil contamination density above  $10 \text{ Ci/km}^2$ , that stipulating for the need to run on-going radiation control over wood resources at particular sites.

Out of the structural parts of wood plants of both coniferous and deciduous breeds, the greatest specific activity is observed in leaves, needles, branches, bast, and a bark.

The intensity of radionuclide transfer from soil to wood plants, as well as the level of their concentration in the organs and tissues depend on a variety of factors, among which is radioisotope solubility along with the physical and chemical properties of radioisotopes and the forms of their fall-outs. Natural and climatic conditions are of critical importance. The latter impact significantly the coefficients of radionuclide transfer into the structural

parts of wood plants at the identical density of Cs-137 contamination and the period duration for restoration of environmental, social and economic functions of the forest after radioactive impact. This period will be much shorter in forest-steppe and steppe zones, as compared to those of mixed coniferous-broad-leaved and taiga forests.

Research on Cs-137 migration in forest biogeocenoses shows that a decisive factor that impacts the intensity of Cs-137 transfer into the wood of main forest-forming breeds and other components of forest ecosystems is the regime of soil moistening.

The radioecological characteristics of forest types serves as the basis to develop radiation and environmental safe modes/ technologies for forest utilization in the areas contaminated. The revealed dependences make it possible to manage radionuclide migration in forest ecosystems by way of forming the plantings of certain structure, while running the forestry.

For all wood structures and types of vegetation conditions, the increased value of Cs-137 specific activity is observed in mulch (by 5–10 times more than in wood). It negatively impacts the levels of contamination of forest products (mushrooms/ berries/herbs). The majority of edible fungi accumulates Cs-137 by 10 times more than the mulch and by 10 to 100 times more than the top-soil mineral horizon.

The high level of radioactive contamination of the mulch originates a situation when radionuclide concentration in smoke aerosols during forest fires may increase many times, creating the effect of threat for public exposure and secondary contamination of other areas. However, the estimates show that a radiological threat in this case is low.

Restriction of forestry activity, reduction in procurement of wood and minor forest resources, secondary forest utilization and that of its other kinds causes certain difficulties for the public and workers of the forestry.

### 3. DOSE LOADS FOR PARTICIPANTS OF ELIMINATION OF ACCIDENT CONSEQUENCES (EAC) AND FOR PUBLIC

#### 3.1. Exposure Doses of Participants in Activities in ChNPP Zone

Above 300 people from among personnel of the nuclear power plant (ChNPP) and firemen were affected by acute radiation immediately after the accident. Experts from EMERCOM of Russia, ChNPP and the clinical department of the Biophysics Institute who arrived at the place of accident were involved in initial diagnoses. Proceeding from the original clinical checkup, 237 sufferers were diagnosed to have “acute radiation sickness”; afterwards, the diagnosis was confirmed for 134 people. The majority of sufferers were urgently transported to Moscow clinical hospital No.6 that comprised the specialized department of the Biophysics Institute.

From the very first days following the accident, large contingents of people were involved in the activities in the ChNPP zone. Overall, nearly 120,000 people participated there in 1986. In some sites, such as the Shelter, the work was performed in three shifts involving up to 10,000 people in a shift at certain periods. It became possible to run proper dosimetry control of the participants in the ChNPP zone only some months after the accident. However afterwards, major work on reconstruction of the obtained doses was effected. See Table 3.1 for the results.

Table 3.1.

**Average individual and collective doses by various contingents of witnesses and EAC participants at ChNPP in 1986**

Contingent	Overall Number, people	Sample Volume, people	Number of People with a Certain Dose, %	Average Dose, Gy	Collective Dose, man-Gy
Patients of Clinical Hospital No.6	133	133	100	3.4	450
Other Witnesses of the Accident (ChNPP Internal Sub-Units)	658	658	100	0.56	370
ChNPP Personnel	2 358	2 358	100	0.087	210
US-605*	21 500	8 750	41	0.082	1 760
PA “Industrial Complex”**	31 021	26 296	–	0.0065	200
Military	61 762	61 762	–	0.11	6 800
<b>All Contingents</b>	<b>117 432</b>	–	–	<b>0.083</b>	<b>9 800</b>

\* US-605 – A specialized building enterprise of the USSR Ministry of Middle Machinery that performed the Shelter construction.

\*\* PA “Industrial Complex” – The enterprise of the USSR Ministry of Middle Machinery that performed coordination of and activities on radiation safety provision in the 30-km zone.



The majority of the RF participants in the elimination of accident consequences relate to the cohorts of personnel from the US-605 enterprise (construction of the Shelter), PA “Industrial Complex” and to the “Military”.

Unfortunately, a considerable part of dose loads formed not only during the activities vital from the standpoint of minimizing the accident consequences but also when carrying out the unjustified operations, such as entire decontamination of the Pripjat city. Regardless of the measures taken to restrict exposure for the participants in the activities, part of them was affected by radiation in the doses of the order of maximum permissible level, that is 250 mSv. Though, the average doses for the entire contingent of the 1986 liquidators are estimated much lower.

### ***3.2. Public Exposure Doses***

The exposure dose for the public of Russia is assessed on the basis of the data of radiation and hygienic monitoring run by the Sanitary-and-Epidemiological Services. It is also based on the estimate methods developed during the past 10 years by the experts of the Ramzaev Research Radiation Hygiene Institute (RRHI) (St. Petersburg) jointly with the leading experts from other institutes and agencies.

On-going radiation and hygienic monitoring comprises as follows:

- Hygienic monitoring of the food allowance, drinking water, agricultural production of personal subsidiary plots;
- Monitoring of internal/external exposure doses for critical public groups; estimates and expert dose assessments;
- Control of sanitary-and-hygienic and epidemiological conditions; running sanitary and preventive actions;
- Improving the material and technical basis; metrological provision for control services; and advanced training of experts.

The research shows that the main patterns for exposure dose forming described in the work [12] have proved to be true on the whole, including with respect to the impact of protective measures. For example, it was possible at initial stages to reduce significantly the internal exposure doses for the residents in the areas of the Bryansk region contaminated in soil by Cs-137 ( $> 15 \text{ Ci/km}^2$ ), owing to continuous monitoring of foodstuffs and operative arrangements for appropriate adequate measures of public protection. As of today, the situation has changed (Fig.3.1) due to the elimination of apparent distinctions in the intensity of protective measures.

To estimate the public exposure doses due to the Chernobyl accident, Rospotrebnadzor’s RRHI jointly with the experts from other institutes developed and approved within the period of 1993–2005 a number of methodical documents. Among them are the Methodical instructions for estimating the average annual effective exposure doses, the doses accumulated for the period of 1986-2005, and the doses of thyroid exposure among residents of the RF localities suffered from radioactive contamination as a result of the accident at ChNPP.

At present, the catalogues on annual and accumulated doses, as well as the reference-books on average doses stipulated by iodine-131 accumulation in the thyroid of the

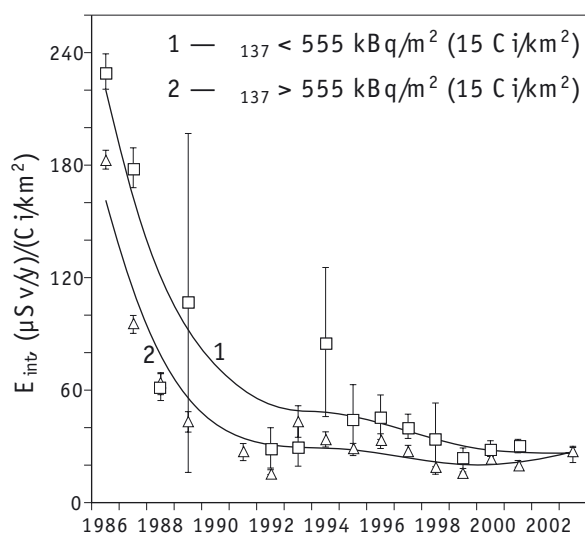


Fig. 3.1. Dynamics for  $\sigma_{137}$  normalized internal exposure dose for the population of the Bryansk region (based on the data of WBC measurements)

residents of different age are published. For the majority of the country's regions affected by radioactive contamination resulted from the Chernobyl accident, including the Bryansk region. Due to apparent contribution of the thyroid exposure, the thyroid doses and accumulated effective doses were estimated for six age groups.

Table 3.2 illustrates the current radiation status.

Table 3.2.

**Distribution of the Bryansk region's localities with respect to the values of actual annual doses in 2004**

Parameter	Dose Intervals, mSv/year			
	< 0.3	0.3–1.0	1.0–5.0	> 5.0
Number of Localities	468	409	96	–

The correlation between external and internal exposure doses is presently much defined by the soil type. In the Bryansk region, the most radio-contaminated region of Russia where sandy and sabulous soils prevail, internal exposure contributes approximately as much to the cumulative dose as external one. In the chernozem zone, the contribution of internal exposure to the cumulative dose does not exceed 10 %, as a rule. Strontium-90 contribution to the cumulative dose of public exposure does not exceed several percent.

The estimates of current average cumulative effective doses (ACED) range from units to hundreds of mSv. Table 3.3 displays the distribution of the Bryansk region's localities with respect to the ACED value for various age groups of the population at the moment of the accident.

Table 3.3.

**Distribution of the Bryansk region's localities with respect to the ACED value for various age groups in 1986–2005**

Intervals of Accumulated Doses, mSv	Age at the moment of accident, years					
	< 1	1–2	3–7	8–12	13–17	> 17
	Number of localities					
< 35	405	460	546	594	621	629
35–70	297	287	263	255	244	240
70	271	226	164	124	108	104

It should be noted that contribution of the Chernobyl content for the overwhelming majority of the localities is not dominating in the structure of public exposure from all sources (Table 3.4).

Table 3.4.

**Contribution of various sources into the average annual effective exposure dose for the population residing in the Bryansk region's localities with different levels of radioactive contamination by Cs-137 (2003), %**

Range of Contamination Density, Ci/km <sup>2</sup>	Operation of Ionizing Radiation Sources	Human-Induced Background	Natural Sources	Medical Sources
<b>All localities of the region</b>	<b>0.022</b>	<b>3.2</b>	<b>86</b>	<b>10.8</b>
1–5	0.022	4.2	85	10.7
5–15	0.020	13.6	77	9.6
> 15	0.016	30.4	62	7.8

## 4. MEDICAL CONSEQUENCES OF THE ACCIDENT

The health status of people affected by the accident is the most important issue, when estimating its consequences. Such a question as how many people died as a result of the accident and how many more might die is of interest to the public, scientists, mass media and politicians. The Chernobyl forum held in Vienna in September 2005 has concluded that the total number of people who may die due to the exposure caused by the Chernobyl accident will not exceed 4000 people. The figure covers the employees of emergency response services and those who reside permanently in the most contaminated areas and includes 50 workers who died of acute radiation sickness in 1986 and due to other reasons in the years that followed and 9 children who died of thyroid cancer. On a conservative estimate, 3940 out of more than 600,000 people comprising 200,000 employees involved in the 1986–1987 emergency-rescue and restoration activities, 116,000 evacuees and 270,000 who reside permanently in the most contaminated areas may die of cancer developed as a result of radiation.

The confusion and overestimate of the death-roll due to the accident at the ChNPP was explained by the fact that thousands of the workers involved in the elimination of accident consequences and those who lived in the contaminated areas died for natural reasons for the period following the year 1986, and their death had nothing to do with radiation. However, the anticipation of indisposition and the tendency to associate all health problems with radiation effects has created the situation when the number of deaths stipulated by the Chernobyl accident is considered to be higher.

### 4.1. Sufferers from Radiation Damages in the First Days

In the first two days following the accident, 237 people with symptoms of acute radiation sickness (ARS) were delivered to the clinics of Moscow and Kiev. The ARS sign was at least minimum marrow affection which could be revealed by decrease in the number of lymphocytes in peripheral blood. Afterwards, the initial diagnosis was confirmed for 134 patients (Table 4.1), as a result of careful clinic-and-laboratory checkup. The most affected workers of the emergency teams (129 people) were transported to clinical hospital No. 6; the preliminary diagnosis “ARS” was confirmed for 108 persons.

Table 4.1.

**Distribution of ARS cases with respect to its heaviness, outcome, and place of treatment**

Extent of Heaviness	Number of Patients	Outcome		Place of Treatment	
		Recovery	Death	Moscow	Kiev
I	41	40	1	23	18
II	50	44	6	49	6
III	22	15	7	21	1
IV	21	7	14	20	1
<b>Bcero</b>	<b>134</b>	<b>106</b>	<b>28</b>	<b>108</b>	<b>26</b>

During the first 3 months, 28 persons died; 19 of them died due to heavy skin beta-damages and 2 persons — due to fatal complications of radiation sickness of considerable heaviness (loss of blood, secondary disease during the marrow transplantation).

All the patients who underwent treatment in the clinical department of the Biophysics Institute were regularly examined by the clinic experts. The examination showed that by frequency and nature of the disease (general somatic or oncological), the ARS patients were close to their contemporaries from the similarly examined group with lesser doses for whom the ARS development was not confirmed. No grounds exist for searching special diagnostic measures and special treatment for diseases usual for persons of their age or sex.

In the remote periods, the ARS patients had as the residuals the dystrophic or ulcerous processes in the sites of local radiation injuries that required the re-treatment. Twelve persons were revealed to have cataracts that required operative treatment with successful transplantation of the lens. In all cases, the  $\gamma$ -exposure doses in the eye area were above 2 Gy.

For the overall period of 1987–2005, another 22 people from among the liquidators, who had survived after ARS, died for different reasons. In 3 cases, it were neoplasms; in the rest ones — the death was caused by usual diseases (essential hypertension, injuries, etc.). The majority of the ARS survivors are active in life and support contacts with the doctors from the clinic with pleasure.



Characterizing the operative help rendered to the victims, it should be noted that the diagnostics, the first aid, the medical-and-evacuation measures and the activity of the emergency team were professionally performed. Treatment of the majority of sufferers in clinical hospital No.6 was based on the previous experience and was adequate to the nature and heaviness of injuries. In August, 1986, the world medical public highly evaluated comprehensive and objective information on the treatment of sufferers.

*“The USSR has presented comprehensive and very precise information on the Chernobyl victims... The Committee believes it to be indebted to the authors of the report for their readiness to share their experience and is eager to especially point out their professional skills and human compassion demonstrated in association with so tragical events”.*

The 1988 UNSCEAR Report to the UN General Assembly

## 4.2. Results of Radiation and Epidemiological Research

The activities for organizing a long-term observation of the individuals affected by radiation started in June, 1986 on the basis of the RAMS Medical Radiological Research Center (MRRC) located in Obninsk.

The Russian State Medical-and-Dosimetry Register (RSMDR) is the unique medical information and analytical system both by scale (more than 600,000 registered citizens of Russia) and by territorial coverage (the RAMS MRRC annually accepts the personal data of every registered individual from all subjects of the Russian Federation). Apart from it, the Biophysics Institute gathers the data on the nuclear industry's personnel who was involved in the elimination of the Chernobyl accident. As of 2005, ~14000 people are observed in the branch register. The average contribution of Chernobyl irradiation to the total accumulated dose for the professionals of the branch is insignificant (<70 mGy).

To monitor the dynamics of sickness rate, disability or mortality of the persons registered, the basic analytical system has been developed. Its aim is to form and analyze such objects of research as population, cohort, and group of people depending on a wide spectrum of the parameters, namely: observation time, area, sex, age, nosologic forms, levels of radioactive contamination, and exposure doses. Special attention is given to define the importance of radiation impacts at the background of other adverse epidemiological factors, as well as to assess the "screening effect", i.e. an eventual growth of disease revealing at the increase in scale and depth of medical examinations of the public.

### 4.2.1. Current Status of RSMDR State Databases

As of March 1, 2005, the RSMDR covers 614,887 people, including 186,395 liquidators; 9,944 evacuees; 367,850 people who reside in the most Cs-137-contaminated areas (above 185 kBq/m<sup>2</sup>) of the Bryansk/ Kaluga/ Tula/ Oryol regions; 35,552 children of the liquidators; and 15,146 people resettled (Fig. 4.1).

Virtually half of the entire RSMDR contingent is registered in the Bryansk (~40 %) and the Kaluga (~10 %) regions (Table 4.2).

The register's basic database comprises personal medical-and-dosimetry information on all individuals registered. It stores above 8 million diagnoses of the diseases revealed for the period of 1986–2004.

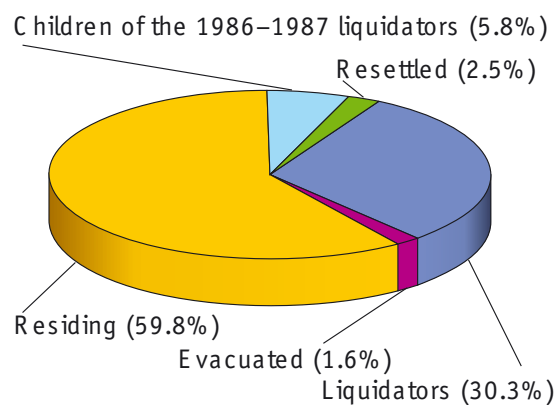


Fig. 4.1. Distribution of people registered by RSMDR with respect to accounting groups

Table 4.2

**Size distribution of the RSMDR contingent over regional centers  
and agency registers**

REGION	Number of Registered People	% of the Total Number of Registered People
NORTHERN Region	8 441	1,4
NORTH-WESTERN Region	14 843	2,4
CENTRAL Region excluding four “most contaminated areas”	33 002	5,4
Bryansk Region	243 452	39,6
Kaluga Region	58 848	9,6
Oryol Region	18 548	3,0
Tula Region	50 522	8,2
VOLGA-VIATKA Region	14 077	2,3
CENTRAL CHERNOZEM Region	14 161	2,3
VOLGA Region	27 042	4,4
NORTHERN CAUCASIA Region	40 169	6,5
URALS Region	28 312	4,6
WESTERN SIBERIA Region	15 996	2,6
EASTERN SIBERIA Region	4 090	0,7
FAR EAST Region	2 696	0,4
Ministry of the Interior of Russia	8 760	1,4
RF Ministry of Defense	4 348	0,7
RF Federal Security Service	1 449	0,2
RUSSIAN RAILWAYS (the former RF Ministry of Railway Communications)	3 587	0,6
Rosatom	22 544	3,7

The age and sex content of the RSMDR contingent is as follows: men – 382,704 (62.2 %); women – 232,183 (37.8 %); children – 75,175 (12.2 %); teenagers – 29,400 (4.8 %); and adults – 510,312 (83.0 %).

The age distribution of the RSMDR contingent (Fig. 4.2) features two peaks: the first one — in the age of 10–14 years and the second one — in the age of 50–54 years. The latter group involves a lot of liquidators, namely 54,282 persons (29.1 % of their total number).

#### *4.2.2. Basic Results of RSMDR Data Analysis*

Traditionally, the basic results of the RSMDR research activity are taken into account for two contingents of observation: the liquidators of the Chernobyl consequences and the public.

The most discussed radiation and epidemiological issues of the Chernobyl accident are as follows:

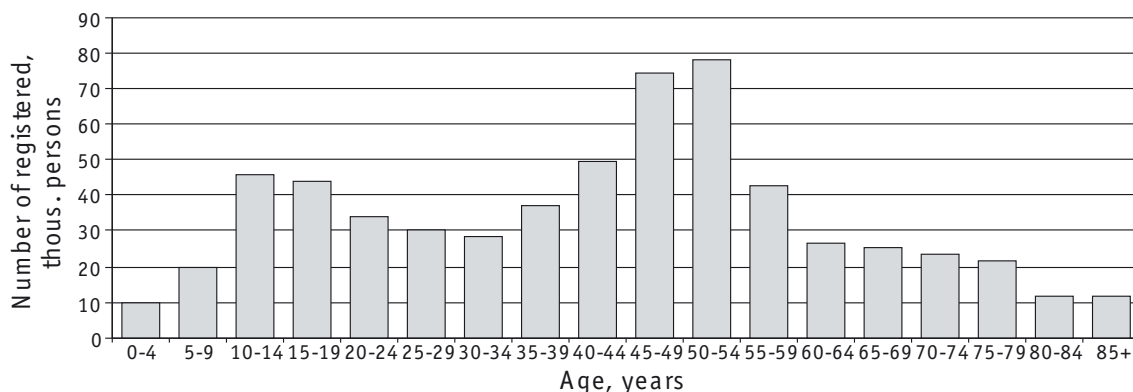


Fig. 4.2. Age distribution of people registered by RSMDR as of March 1, 2005

- Thyroid cancer in the radio-contaminated areas;
- Development of leukaemia among the liquidators and the public;
- Eventual interaction between non-oncological sickness rate (mortality) and radiological effects.

**Thyroid cancer.** The growth of thyroid cancer among children (0–14 years in 1986) residing in the contaminated areas is one of the most evident consequences of the accident.

Analysis of the thyroid cancer dynamics for the public from the Bryansk/ Kaluga/ Tula/ Oryol regions has revealed significant increase in this index in all age groups: by 2–3 times for the adults and by more than 10 times — for children and teenagers. To reveal the role of radiation factor from cumulative impact of all factors (including the screening effect), the RSMDR carried out large-scale epidemiological research by using state-of-the-art technologies for cohort investigations. The results of the work show that 122 cases (54%) out of 226 thyroid cancers revealed during 1991–2003 among children of the Bryansk region (at the moment of the accident) are most likely stipulated by radiation.

**The 2001 National report:** *Overall, the adverse prediction for thyroid cancer has proved to be true. 170 thyroid cancers are revealed among children of the Bryansk region (at the moment of the Chernobyl accident). It is highly probable that about 55 of them are stipulated by radiation effects from incorporated <sup>131</sup>I. In a number of other regions where increase in the thyroid cancer rate is revealed as well, dependence of the sickness rate frequency on the dose has not been fixed.*

**Development of leukaemia among the liquidators and the public.** Among radiogenic malignant neoplasms, leukaemia has the maximum radiological risk and the minimum latent period. Therefore, great efforts have been made to analyze the development of leucoses among the contingents registered.

**The 2001 National report:** *Increased development of leucoses among the liquidators has been discovered; 145 leucoses are revealed, 50 of which are stipulated by the radiological factor.*

The assessments pointed out by the 2001 National report related to the entire cohort of liquidators (179,000 people). In the subsequent period, profound research within the scope



of the register was conducted for the cohort of liquidators with the dosimetry data that confirmed the available effect and the time range for its realization.

The epidemiological analysis comprises the cohort of liquidators living in the European part of Russia (71,870 people) for whom individual information on the obtained external exposure doses (the 107 mGy average dose) was available. The research results are as follows. Only the liquidators who received the dose above 150 mGy should be related to the risk group of leukaemia development stipulated by radiation. Secondly, the risk of radiation induction of leucoses was realized during the first ten years after the Chernobyl catastrophe. The two periods of observation are distinguished: 1986–1996 and 1997–2001. Comparison was performed by the frequency of leucosis development among the liquidators of the two groups, namely: those with the obtained external exposure doses **up to** 150 mGy and those with the doses **above** 150 mGy. The research showed that during the first ten years of observation, the leucosis development in the second group was by 2.2 times higher than in the first one. During the second period of observation (1997–2001), no distinctions between the above mentioned groups in the frequency of leucosis development were revealed. Therefore, the RSMDR scientists insist that the revealed effect is conclusive.

Table 4.3.

#### Radiological risks of leucoses for liquidators

Period of observation	1986–1996				1997–2001			
	0–45	45–90	90–150	150–300	0–45	45–90	90–150	150–300
Dose groups (mGy)	0–45	45–90	90–150	150–300	0–45	45–90	90–150	150–300
Average doses (mGy)	17	67	103	208	17	65	104	208
Number of leucosis incidence	8	4	5	19	4	3	3	5
Number of observations, man-years	126 750	93 915	121 634	174 437	79 970	56 459	68 741	94 847
Relative risk (90% of CI)	1.0 –	0.7 (0.2, 1.8)	0.7 (0.2, 1.6)	1.7 (0.9, 3.6)	1.0 –	1.1 (0.3, 3.7)	0.9 (0.2, 3.1)	1.1 (0.4, 3.3)
Comparison of two groups (90% of CI)	1 –	2.2 (1.3, 3.8)	1 –	1.1 (0.4, 2.6)				
Excess relative risk (per Gy) (90% of CI)	5.3 (0.0, 22.0)	0.1 (–3.4, 13.2)						

The analysis of leucosis development among the public of the five most contaminated districts of the Bryansk region (Gordeev/Zlynkov/Klintsov/Krasnogorsk/Novozybkov) has shown that it correlates with a spontaneous level of sickness rate for entire Russia within the limits of statistical errors. The trend of leucosis development (for the overall public) from the exposure dose is close to zero and is not statistically significant.

**Interaction between Non-Oncological Sickness Rate (Mortality) and Radiological Effects.** The latest data of the Hiroshima/Nagasaki register makes it possible to assume the availability of dose dependences (at doses above 0.5 Sv) for the frequency of non-oncological development. First, it is a question of cardiovascular pathology.

Research on dose dependences of non-oncological development among the public living in the contaminated areas has not revealed a statistically significant interaction between the sickness rate indices and the dose load for the majority of classes. Though, it has been revealed between the sickness rate and the thyroid exposure dose for such diseases as thyroid goiter and thyroidism (including autoimmune) for many age and sex groups (especially for children and teenagers at the moment of the accident).

The RSMDR experts jointly with the Sasakava Fund (Japan) carried out the research on the frequency of non-cancer thyroid diseases among the cohort of children from the Kaluga and Bryansk regions (2,457 persons) for whom individual data on the doses of thyroid exposure was received in May–June, 1986. The average dose of thyroid exposure from incorporated iodine-131 made up 132 mGy. It was established that the frequency of diffuse goiter development among the cohort under investigation had statistically significant dose dependences.

The RSMDR also runs the research on radiological risk assessments of the diseases of circulatory system among the liquidators. Statistically significant dependences of mortality caused by the diseases of circulatory system on the exposure dose were fixed within the scope of the above research. It has been established that the liquidators who received the external exposure dose above 150 mGy for the period no more than 6 weeks of stay in the 30-km zone of the ChNPP in 1986 have a statistically significant radiological risk of cerebrovascular diseases.

The data received by the RSMDR experts with respect to radiological risks of non-oncological diseases is of preliminary nature and requires further clarification during radiation-and-epidemiological research.

As for the general indices of the health status of people affected by radiation resulted from the Chernobyl accident, the radiation-and-epidemiological research makes it possible to ascertain the following.

#### *Liquidators*

The share of liquidators who are practically healthy constantly decreases. At present, 78.4 % of them suffer from chronic diseases (they have the 3<sup>rd</sup> health group). The indices of primary sickness rate by different disease classes for the liquidators exceed the control all-Russian indices by a number of them. For instance, diseases of the endocrine and circulatory systems, mental insanity, nervous and musculoskeletal diseases and those of connective tissue, as well as diseases of digestive organs are more often registered among the liquidators. The difference in the indices of sickness rate for the liquidators and the appropriate control parameters (for the adult male population) decreases annually, that being stipulated, first, by the reduction in quality of clinical examination of the liquidators.

**Disability.** The total number of invalids in 2003 made up more than 66,000 people, that being about one third of the general number of liquidators registered by RSMDR. At present, the number of disabled liquidators of the first group reaches 2.7 %; that of the second and the third groups makes up 51.9% and 45.4%, respectively. The disability structure has remained quite stable recently. For instance, contribution of diseases of the circulatory system during these years has been 39.2 %; that of the nervous system — 28.9 %; mental insanity — 9.3 %; malignant neoplasms — less than 2 %. The present picture mismatches with the disability structure of able-bodied citizens of the Russian Federation where dis-

eases of the circulatory system, malignant neoplasms and injuries/poisonings rank first, second and third correspondingly. The share of neuropsychic diseases in the structure of liquidators' disability is by more than 2 times higher than that of the able-bodied citizens.

**Mortality.** The total number of the liquidators who had died by the end of 2003 made 22,998 people (12.3 % of those registered). No significant excess of relative risk over 1 was registered as regards to total mortality rate, i.e. mortality indexes for liquidators do not exceed the control levels for the Russian males. The main causes for the liquidators' death during the overall post-accident period were diseases of the circulatory system (34 %), injuries/ poisonings (29 %) and neoplasms (13 %). The fraction of neoplasms in the mortality cause structure is a little below for liquidators than for the Russian males of working capacity age (14 %).

**Solid carcinomas.** 4,116 liquidators with malignant neoplasms are presently registered by the RSMDR. Its data analysis shows that for the past 11 years the spontaneous disease incidence in the cohort of liquidators has correlated with the sickness rate of corresponding age groups of Russia's population within the limits of statistical errors.

#### *The Public Living in Radio-Contaminated Areas*

**Health Groups.** For the past five years, the share of people who are practically healthy among the public from the contaminated areas has constantly decreased and made up 17.8 % by the end of 2003.

**Sickness Rate.** The basic tendency for the past years of observation has been the growth of sickness rate for the children from the contaminated areas of Russia (general disease incidence, injuries, poisonings and some other consequences of external impacts, the diseases of digestive organs, those of the urinogenital system, skin diseases and those of subcutaneous fat). Among the adult population from the areas under analysis, it is possible to distinguish a tendency for the growth of sickness rate indices in such nosologies as infectious and parasitic diseases, those of the circulatory system and digestive organs. The above changes have not entailed the change in the structure of disease incidence.

**Mortality.** Both before and after the accident, the indices of general mortality for each of the areas under consideration were below the appropriate indices for the Russian Federation. In the post-accident period, this index is of maximum value for the Tula region; the mortality indices for the Bryansk/ Kaluga/ Oryol regions are rather similar. The nature of changes in the RF death rate indices fully corresponds, on the whole, to that of each of the contaminated areas.

**Solid carcinomas.** The comparative analysis for age and sex indices of solid carcinoma development in the contaminated areas of the Bryansk region has shown the lack of distinctions from the all-Russian indices within the limits of statistical errors. The radiation-and-epidemiological analysis of cancer development has not revealed any dose dependences. The analysis of the mammary gland cancer development among the female population of the Bryansk region was conducted. No dependences of this pathology development on the external exposure dose were revealed for the 1986–2003 period of observation.

The results of research run within the scope of the register are regularly published in a special bulletin as well as in scientific magazines. The results have been submitted to such authoritative organizations as the World Health Organization (WHO), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Commission on Radiological Protection (ICRP), etc.

### ***4.3. Activity of Advisory Councils on Revealing the Causation between Diseases and Radiation Effects***

Most often, it is a challenge to reveal the reasons of a disease. The situation becomes even more complicated in the cases of the individuals affected by radiation. Radiation does not entail the occurrence of any new diseases and syndromes (except for acute or chronic radiation sickness); it promotes development of the diseases observed even among non-irradiated patients. If one can be confident enough to speak about the cause-effect chain at large exposure doses, the occurrence of negative health consequences at low exposure doses is of probabilistic nature. Therefore, it is rather difficult to make a decision with regard to a particular patient.

The Federal Law “**On Social Protection of the Citizens Affected by Radiation Resulted from the Chernobyl Catastrophe**” establishes the hierarchy of benefits depending on the category. Among the latest are as follows: citizens suffered from radiation sickness or other diseases associated with radiation effects; invalids due to the Chernobyl catastrophe; the 1986–1987 and 1988–1990 participants in elimination of the accident consequences; evacuees, etc. The measures for social support of different categories of the citizens are most vital for those suffered from radiation sickness and for those who has become disabled due to the Chernobyl accident. The same law envisages that establishing the causation between disability and the Chernobyl consequences should be performed by inter-agency advisory councils and military-and-medical commissions, as well as by other structures defined by the RF Government.

In Russia, 12 Inter-Agency Advisory Councils (IAC) have been created on the basis of leading clinical and research institutes, namely:

- Saint Petersburg (EMERCOM’s All-Russian Center of Emergency and Radiation Medicine);
- Russian (the All-Russian Research Center of Roentgen Radiology);
- Moscow (Institute of Biophysics );
- Rostov (the Rostov State Medical Institute);
- Krasnodar (the Krasnodarsk Regional Clinic Hospital);
- Ekaterinburg (the Ekaterinburg Regional Hospital No.2);
- Chelyabinsk (the Chelyabinsk Regional Hospital);
- Ozersk (Affiliate of the Institute of Biophysics);
- Volgograd (the Volgograd Regional Clinic Hospital);
- Novosibirsk (the Novosibirsk State Regional Clinic of Radiation Pathology);
- Itai (the Regional Hospital No. 2 of the Health Committee of the Altai Administration);
- Far East (the Regional Clinic Hospital).

The IAC aim is to reveal causation between diseases/ disability/ death and exposure of the citizens affected by radiation as a result of the Chernobyl catastrophe (the Russian/ Rostov/ St. Petersburg/ Ekaterinburg/ Krasnodar/ Novosibirsk/ Far East IACs); the 1957 accident at SPA Mayak; radioactive discharges into the Techa river (the Chelyabinsk/ Ozersk IACs); and nuclear tests at the Semipalatinsk testing area, as well as among the children of the 1<sup>st</sup> and 2<sup>nd</sup> generation of the citizens (the Altai IAC), and among the persons professionally involved in the contacts with the radiation-producing equipment (the Moscow/Ozersk IACs).

Re-consideration of expert questions in the disputable cases is performed by the Saint Petersburg Council. The majority of people who have appealed to IACs (75.9 %) are the participants in the elimination of the Chernobyl consequences. In total, 48.5 thousand expert matters were considered for the period of 1990-2004. The majority of the matters was reviewed by the five advisory councils, namely: Saint Petersburg (26.8 %), Russian (23.8 %), Rostov (11.2 %), Volgograd (13.8 %) and Chelyabinsk (11.2 %).

The lack of experience led to the fact that in the first years the diseases developed among the 1986–1987 liquidators were associated by IACs with radiation effects. However, ideas of radiation cause of the diseases varied with experience accumulation; therefore, re-examination took place afterwards. As a result, the number of positive decisions decreased by all classes of diseases, except for neoplasms. Diseases of the circulatory system (54 %), neoplasms (11 %) and those of the nervous system (about 10 %) contribute most to the structure of diseases among the re-examined individuals.

The state has undertaken the obligations to pay benefits to the relatives of the liquidators who died, should it be established that the cause of death was the disease stipulated by involvement in the activities in the ChNPP zone. Consideration of this item also is a subject of activity of the advisory councils. As the reasons for the liquidators' mortality, diseases of the circulatory system rank first, followed by neoplasms and by injuries/poisonings, that corresponding to the average world indices. As a rule, the advisory councils confirm the dependence on radiation effects in the case of death from diseases of the circulatory system and from neoplasms and reject it in the case of death from injuries and poisonings, infectious diseases and those of the urinogenital system.

The IAC activity interfaces with objective difficulties defined by the two factors:

- High motivation of the individuals who apply to the experts for the cause to be established;
- Actual impossibility to reject eventual causation by a wide class of diseases.

In this connection, the actual goal is to correlate in conformity with the current research data the normative basis for expertise of disease causation with radiation effects.

## **5. ELIMINATION OF CATASTROPHE CONSEQUENCES IN THE RUSSIAN FEDERATION**

The basic volume of activities on the catastrophe elimination is solved within the scope of state programs. Since 2001, these activities have entered the state program «Elimination of Consequences of Radiological Catastrophes» which also tackles the issues on mitigation of the South Urals accident consequences and those of nuclear tests. As mentioned above, the basic volume of program activities covers construction of social sites, development of and provision for the medical care enterprises. The protective measures aimed to decrease radiation effects focus on agriculture, forestry and radiation-and-hygienic monitoring. Social and psychological rehabilitation of the public is among the program priorities.

A number of vital kinds of activities on implementation of the liabilities assumed by the state also have entered the subprograms covered by such general programs as «Accommodation» or «Children of Russia». The RF subjects, local governments and public organizations perform considerable part of activities on mitigation of the accident consequences. International cooperation has been an essential element of all work milestones.

### ***5.1. State Programs on Elimination of Catastrophe Consequences***

During 1992–2001, the RF Government adopted three federal target programs for elimination of the Chernobyl consequences, four programs on children's protection from the Chernobyl consequences, and a program on accommodation provision for the liquidators of the Chernobyl accident. Apart from it, the Joint Activity Program aimed to mitigate the Chernobyl consequences within the framework of the Russian-Byelorussian Union (Table 5.1) was approved in 1998.

The budget includes 1.7 billion dollars in federal funds for program actions. Moreover, extra funds were secured by the RF Ministry of agriculture, the RF subjects and from off-budget sources.

#### ***5.1.1. Programs on Elimination of Chernobyl Consequences***

The main goal of the programs on elimination of the Chernobyl consequences during 1992–2001 was to reduce as low as possible negative medical, social and psychological effects of the accident for the public and the liquidators; to perform both environmental and economic remediation of radio-contaminated lands; and to recover normal living conditions in a number of areas.

Though the programs targets remained the same, their content underwent significant changes. In the first years, relocation was regarded as one of the priorities. Considerable decrease in the relocation promotion; understanding that termination of the construction at all sites under review would represent much difficulty, as well as concentration of the protective measures solely on agriculture and forestry is typical of the years 1993–1995. Overall, this period is characterized by a significant decrease in the resource provision for the program, as only urgent measures were funded during 1996–1997. Moreover, the program implementation in 1998–2001 was affected by an economic crisis.

Table 5.1

**Periods for implementation of state programs**

Program Name	Period
1. Unified State Program on Protection of RF Population from Chernobyl Consequences for the Years 1992-1995 and for the Period Until 2000.	1992–1995
2. Urgent Actions on Protection of RF Population from Chernobyl Consequences for the Years 1996–1997.	1996–1997
3. Federal Target Program on Protection of RF Population from Chernobyl Consequences for the Period Until 2000.	1998–2001
4. State Union-Republican Program on Children’s Health Protection from Chernobyl Consequences for the Years 1991–1995.	1991–1995
5. Federal Target Program «Children of Chernobyl» as Part of the Federal Program «Children of Russia».	1993–1997
6. Federal Target Program «Children of Chernobyl» for the Years 1998–2000.	1998–2000
7. Federal Target Program «Children of Chernobyl» for the Years 2001–2002.	2001–2002
8. Federal Target Program «Dwelling Provision for Liquidators of the Chernobyl accident for the Years 1995–1997».	1995–2001
9. Joint Activity Program for Mitigation of Chernobyl Consequences within the Scope of Russian-Byelorussian Union for the Years 1998–2000.	1998–2001

Stage-by-stage concentration of the efforts on the most contaminated lands is typical of target programs. Until 1998, the programs extended to include 14 RF subjects contaminated as a result of the Chernobyl accident. Since 1998, the implementation of practical actions of the program has focused in the four regions, such as Bryansk/ Kaluga/ Oryol/ Tula.

Overall, a considerable volume of activities was performed within the scope of the program. In 1992–2001, above 1.3 million m<sup>2</sup> of the total dwelling area; general education schools to seat 18,183 pupils; 1,287-bed hospitals; polyclinics designed for 4,995 visits per shift; clubs and culture palaces of 3,960 seats were commissioned.

Great attention during the program implementation in 1992–2001 was given to the arrangements for and performance of effective medical and preventive actions. The programs set the task to establish a system of medical provision for the population living on radio-contaminated lands, the resettlers and the liquidators. The system was assumed to create an optimized scheme covering «a primary clinical examination – an advanced clinical examination - treatment – rehabilitation» as well as its material and technical support.

In 1992, the all-Russian Center for Environmental and Radiation Medicine (RCERM) was established in Saint Petersburg. By the RF Governmental decree, it was given the functions of head organization for rendering medical assistance to the liquidators and the individuals relocated from the radio-contaminated areas of Russia. As of today, above 12,000 individuals suffered from the radiological emergencies, mainly the liquidators of the Chernobyl consequences, from 56 subjects of the Russian Federation have undergone expert examination, treatment and rehabilitation in the RCERM.

Specialized medical assistance to the inhabitants of contaminated areas from the Bryansk/ Kaluga/ Tula/ Oryol regions was rendered on the basis of the Obninsk Medical Radiological Research Center (MRRC RAMS). 3,500 individuals have undergone highly qualified examination and treatment in the MRRC RAMS during the program validity.

Much attention was given to scientific support for the activities. The leading scientific groups of Russia were involved in the scientific work, for instance, MRRC RAMS, the Federal Children's Scientific and Practical Center for Antirad Protection of Russia's Ministry of Health, the Biophysics Institute, Roshydromet's Institute of Global Climate and Ecology, the Saint Petersburg Research Institute of Radiation Hygiene, etc.

In 1992–2000, the entire number of technological, normative and methodical documents were developed, compiled and approved by the appropriate agencies and administrations of the regions concerned. The activities on the organization of radiation and dosimetry monitoring and information and analytical provision for the program were the most vital.

Since 2002, mitigation of the Chernobyl consequences has been performing within the scope of the subprogram «Elimination of the Chernobyl Consequences» that enters the federal target program «Elimination of Consequences of Radiological Emergencies for the Period Until 2010».

The subprogram's main aim is to create normal living and economic conditions (without constraints by the radiation factor) for the public of the areas affected by radioactive contamination as a result of the Chernobyl accident. During elaboration of the program, the more realistic estimates of the state budget were assumed and the more limited goals were envisaged with respect to the construction of social sites.

Taking into account the differentiation of functions or financial powers between the levels of state authorities, the non-profile sites, such as culture/ sports sites, private houses, etc., have been excluded from the program by the proposal of Russia's Ministry of Economic Development, starting from 2005. All sites constructed within the scope of the program (including uncompleted ones) are the state ownership of those RF subjects which territory they occupy.

Within the framework of the subprogram, the following activities were performed:

- Health protection for the citizens affected by radiation;
- Decrease in the levels of public exposure and remediation of the radio-contaminated areas;
- Radiation, sanitary-and-hygienic monitoring of environmental sites and foodstuffs; monitoring of public exposure doses;
- Social and psychological rehabilitation of the citizens affected by radiation, as well as international cooperation, information-analytical and scientific support for the subprogram.

In 2002–2005, above one billion roubles was secured from the federal budget to fund capital investments. For the above period, 35,500 m<sup>2</sup> of the total dwelling area; polyclinics for 930 visits per shift; the 170-bed hospitals; schools to seat 2,289 pupils; the 190 km gas networks; the 15.4 km water supply systems, and a number of other sites began operation in the Bryansk/ Kaluga/ Oryol/ Tula regions.

The basic amount of funds (about 50 %) was spent to implement the actions from the section «Health Protection for the Radiation-Affected Citizens and Their Children of 1st and 2nd Generation».

Main attention was given to equipping additionally the local/ regional medical enterprises that rendered specialized stationary, out-patient or consulting assistance to the citizens affected by radiation, including the liquidators of the Chernobyl consequences. The



equipment covered the state-of-the-art medical and diagnostic facilities, reagents and consumables. Nearly 100 units of highly technological medical equipment was purchased and delivered for medical enterprises of the Bryansk/ Tula/ Oryol/ Kaluga regions.

Within the scope of the program, tens of thousands of citizens obtained highly qualified assistance in the specialized medical enterprises of federal (RCERM, MRRC RAMS, etc.) or regional level (Bryansk/ Tula/ Oryol/ Kaluga regions).

### *5.1.2. Other Specialized Programs*

#### **Programs on children protection against Chernobyl consequences**

Forty sites of children's medical profile, including the 1,771-bed hospitals, polyclinics for 2,670 visits per shift, consulting/ diagnostic/ rehabilitation centers for 1,220 visits per shift, sanatoriums to seat 449 individuals, the 300-seat baby's homes, the children's home and a number of other sites began operation for the period of program implementation in 1992–2002. The funds secured for implementation of the program actions made it possible to fortify the material basis of local/ regional medical preventive enterprises, children's homes, and other sites of children's profile.

To monitor the health state of the children suffered from radiation, an effective three-level system (of local, regional and federal level) for clinical examination was developed and implemented in practical health protection. The annual planned medical examination in the areas under control covered 97–98 % of the children.

Within the scope of the Program, the release of vitaminized foodstuffs for treatment and prophylaxis was arranged. Annually, more than 60,000 children from the contaminated areas obtained vitaminized products.

#### **Dwelling provision programs for liquidators of the Chernobyl consequences**

The aim of the programs is to implement the privileges fixed by law with respect to the dwelling provision for the liquidators who were involved in the elimination of radiological effects, the evacuees (resettlers) or the volunteers who left the radio-contaminated localities.

During the program implementation in 1995–2001, fifteen thousand families were provided with the dwelling apartments. Owing to all finance sources, about 2,400 apartments of the total area above 110,000 m<sup>2</sup> were acquired in 2002–2004 for the participants of the subprogram, above 1,200 apartments being at the expense of the federal budget.

At present, the subprogram implementation mechanisms are significantly updated. In compliance with the Federal Law No.122 dt. August 22, 2004, the social support measures associated with the dwelling provision for the citizens from among the subprogram participants are the Russian Federation's expenditure liabilities. When implementing the 2005–2010 subprogram, the main form of the dwelling provision has become the grants provided to the participants according to the order established by the RF Governmental Decree No. 866 dt. December 29, 2004.

Proceeding from the specified data as of January 1, 2005, the total number of subprogram participants makes up 25,500 families. The amount of federal funding for the program implementation in 2005–2010 reaches 4 billion 142 million roubles. Its realization is assumed to provide nearly 6,000 families of the participants with comfortable accommodation. The new conditions promote successful implementation of the program.

About 1,100 participants improved their living conditions in 2005, owing to the federal budget.

### **Joint activity program for mitigation of Chernobyl consequences within the scope of Federal State**

The first «Joint Activity Program for Mitigation of the Chernobyl Consequences within the Scope of Russian-Byelorussian Union for the period of 1998–2000» covered the following activities: creation of the material and technical basis for common specialized medical assistance; research and practical work in the field of health protection, agriculture, forestry, and environmental monitoring aimed to establish the basis for bringing together the normative, legal and methodical approaches to public protection and remediation of the areas. Overall, the activities on reconstruction of the Medical Radiological Center of the Russian Academy of Sciences (above 5,000 m<sup>2</sup>) and the all-Russian Center of Emergency and Radiation Medicine of EMERCOM of Russia (the 120-bed clinic) were completed. The production of biologically active additives that had medical, prophylactic and adaptogenic properties started at the Russian and Byelorussian facilities. The new components of the Unified Chernobyl register of Russia and Byelorussia were created, etc.

The main target of the 2002–2005 Program was to elaborate a common policy for the two states to mitigate the consequences of the Chernobyl accident and provide its implementation on the basis of creation of the unified normative, methodical and information space, as well as the general system of specialized medical assistance to the sufferers.

981,839.4 Russian roubles (namely: 483,469.2 Russian roubles in Byelorussia and 498,370.2 in the Russian Federation) were secured for the program from the Union budget in 2002–2005. During the program realization, the following results were obtained:

- The material and technical basis for common specialized medical assistance to the radiation-affected citizens from Byelorussia/ Russia was created;
- The fundamentals for the normative and methodical basis of the common policy in agriculture and forestry on radio-contaminated lands and for organizing the radiation and hygienic control of foodstuffs were elaborated;
- The Russian-Byelorussian information center for mitigation of the Chernobyl consequences began operation;
- Production of the foodstuffs with medical and prophylactic properties started.

In accordance with the decision of the Federal State's Council of Ministers (Minutes No. 4 dt. December 21, 2004) and the assignment of the RF Government (No. MF-P12-969 dt. March 5, 2005), EMERCOM of Russia jointly with the Chernobyl Committee of Byelorussia has prepared the Draft Proposal for developing the joint activity program on mitigation of the Chernobyl consequences within the scope of the Federal State for the period of 2006–2010.

#### *5.2. Protective Measures in Agriculture and Forestry*

As mentioned above, a package of protective measures for agriculture that started to be implemented in the most contaminated areas was developed in a quite limited time period. The important factor for effective use of those measures was consideration of soil, climatic and geochemical features of contaminated lands.

**Protective measures for plant cultivation.** The contaminated zone covered the areas with varied soil and climatic conditions and different technologies for agriculture; therefore, the task was set to optimize the use of protective measures, taking into account the peculiarities of farming in different zones. The research made it possible to distinguish the three groups of methods to be used in plant cultivation, namely: agrotechnical, agrochemical and complex (Table 5.2).

Table 5.2.

**Efficiency of Agrotechnical or Agrochemical Protective Methods to Decrease <sup>137</sup>Cs Accumulation in Plant Production**

Action	Modifiable Indices	The efficiency is the ratio of decrease in radionuclide accumulation in plants, number of times
Ploughing	Radionuclide redistribution in topsoil	1.5–2.5
Turnover ploughing	Mechanical transfer of a contaminated layer into the underlying beds	до 5–10
Liming	Change in soil acidity; Ca-saturation of the soil absorbing complex	1.5–2.0
Increased phosphate and potash fertilizing	Change in soil acidity; K increase; change in the extent of saturation	1.5–2.0
Organic fertilizing	Change in the exchange capacity/ content of carbon	1.5–2.5
Use of clay minerals	Increase in the soil sorption capacity and that of competitive impact of K /Ca cations used for the soil span	Light soils: decrease by 1.5-3.0 times in <sup>137</sup> Cs accumulation in plants; other soils: the effect is not observed
Complex use of meliorative substances	Change in soil acidity and carbon content; increase in the extent of saturation and in the content of K /Ca cations	up to 5.0

Protective actions for fodder production. There are two groups of agrotechnical methods traditionally run on the feeding lands, namely: surface or radical improvement for haymakings and pastures (Table 5.3). Traditional actions to increase the herbage efficiency also are effective from the standpoint of decreasing radionuclide accumulation.

**Protective actions for cattle breeding.** The system of protective actions in the cattle breeding includes four groups of methods, namely: organizational, restrictive, veterinary and zoocultural (Table 5.4).

During 1986–1988, the number of actions performed in the agroindustrial production gradually increased. Their number became optimum within the period of 1988-1992. That provided significant decrease in the volumes of products contaminated above the temporary admissible level (TAL). By the early 1990s, they were decreased to 2.5% versus 86 % in 1986 in part of milk; to less than 0.1 % versus 15.2 % in part of meat; and to less than 0.01 % versus 78 % in part of grain.

Table 5.3.

### Efficiency of protective actions on meadows

Kind of actions	Ratio of $^{137}\text{Cs}$ decrease in the herbage, number of times
Removal of the contaminated topsoil	5–15
Ploughing:	
Standard	1.8–3.2
Turnover ploughing	2.0–6.0
Deep	8–16
Disking/Milling	1.2–1.8
Radical improvement	2.7–6.2
Surface improvement	1.6–2.9
Drainage	2.8
Drainage/surface improvement	2.5–5.5
Drainage/radical improvement	3–10
Use of clay minerals for topsoil in the first period following the accident	1.5–2.0
Use of non-traditional meliorative substances, such as zeolit, vermiculite, etc.)	1–2.5



Table 5.4.

**Decrease in  $^{137}\text{Cs}$  Content in cattle-breeding products as a result of countermeasures**

Type of countermeasures	Kind of animals	Kind of product	Decrease ratio, number of times
<i>Restrictive</i>	Cattle	Milk	$\frac{8.3-8.5}{8.4}$
<i>Organizational</i>	Cattle	Milk	$\frac{4.0-4.1}{4.1}$
	Cattle	Meat	$\frac{3.3-3.5}{3.4}$
<i>Veterinary</i>			
Use of Cs adhesives	Cattle	Milk	$\frac{1.5-2.2}{6.9}$
	Cattle	Meat	$\frac{1.9-2.3}{2.1}$
Use of sorbents	Cattle	Milk	$\frac{1.2-2.0}{1.9}$
<i>Zoocultural</i>			
Preslaughter fattening with «pure fodders»	Cattle	Meat	$\frac{2.0-15}{7.7}$
	Horses	Meat	$\frac{1.9-9.5}{5.1}$
	Sheep	Meat	$\frac{2.8-76}{27.2}$
Rational use of haymakings/pastures	Cattle	Milk	$\frac{1.3-10}{4.5}$
Selection of fodders for the ration	Cattle	Milk	$\frac{1.7-2.5}{2.1}$
	Cattle	Meat	$\frac{32-42}{37.2}$

The majority of protective actions performed in plant cultivation and fodder production are typical of intensive agriculture. Therefore, the processes that occurred in agriculture of the contaminated areas reproduced the situation typical for the entire country. Should the economic situation deteriorate, the number of chemical facilities and agromeliorative actions decreases, that entailing an increase in the volumes of contaminated products. For instance,  $^{137}\text{Cs}$  content in the products from the Novozybkov district increased by more than twice in 1995-1996 and by 10 times in 2003–2004 versus the period when the protective actions were performed in optimum volumes (1991–1992).

The situation developed in a similar way in the field of fodder production and cattle breeding products. During the first five-eight years following the accident, radical improvement was widely used practically in all areas affected by contamination. In 1996-2000, the volumes of radical improvement for meadows reduced to 12,800 ha in the Bryansk region. In 2001-2004, the use of this method somewhat increased (20,800 ha) but was practically used only in the seven Southwest areas of the Bryansk region.

The method of preslaughter fattening with «pure fodders» has proved to be highly effective (three-four weeks prior to the slaughter, the ration of animals had a low content of  $^{137}\text{Cs}$ ). The scale of these actions was corrected, proceeding from the data on lifetime definition of  $^{137}\text{Cs}$  content in the muscles of animals, and reached 5 to 20 thousand head of cattle.

Since 1993, large-scale implementation of ferrocin has started both on individual farms and in the public sector of the contaminated areas of the Bryansk region. The following four kinds of preparations are used: powdered ferrocin, bifezh, salt-lick briquettes containing ferrocin; and ferrocin-containing boluses. The use of ferrocin is one of the most effective methods that brings to reduction by four-six times of  $^{137}\text{Cs}$  concentration in milk. 500,000 to above one million head of cattle per year were processed with the ferrocin-containing preparations. That made it possible to preserve the minimum volumes of cattle breed products with excess  $^{137}\text{Cs}$  content during the period of decrease in the rate of running agrotechnical and agrochemical actions. The annual use of preparations provides reduction to the normative level of more than 30,000 tons of milk and 5,000 tons of meat in slaughter weight.

The greatest contamination of agricultural products and, as a result, the volumes of production exceeding the standards were observed in the Bryansk region (Fig. 5.1).

Owing to the implementation of special actions in cattle breeding, such as preslaughter fattening with «pure fodders» or arrangements for stable/ pasture maintenance of animals, the levels of contamination of cattle breeding products constantly decreased. Since 1991, their share in the products that do not meet the standards has not exceeded 10 % from the total production in the contaminated areas. The greatest effect was obtained in grain/ potatoes production. By 1991, decrease to the minimum volumes (less than 0.1 %) of grain production with  $^{137}\text{Cs}$  content less than 370 Bq/kg (Fig.5.1) was achieved. However when transferring to SANPIN 2.3.2.-1078-01, the share of grain that did not meet the new and more strict standards (160 Bq/kg) increased greatly up to 20 % in 2004. Moreover, it should be mentioned that abrupt decrease in the use of mineral fertilizers for grain as well as reduction of the scale of protective actions in recent years have increased the  $^{137}\text{Cs}$  accumulation in grain.

The situation with respect to provision of the production that meets the milk requirements has been and remains the most complicated. Due to the implementation of a package of protective actions and the intensive use of ferrocin-containing preparations, the milk production inappropriate to the standards has reduced to the minimum volumes.

**Contribution of protective actions to reduction of contamination of agricultural production.** Three groups of factors determine the reduction of contamination of agricultural production, namely: natural biogeochemical processes that define a decrease in biological availability in the soil and plant system, protective actions and radioactive decay. The contribution of each factor is evaluated, as applied to the Bryansk/ Kaluga regions (Table 5.5).

In spite of significant improvement in the radiation status and the success achieved when performing the protective actions, agriculture still needs them at present. The six most contaminated areas of the Bryansk region are critical on the territory of Russia. The residents from these localities have nearly 4,000 head of milkers, using about 12,000 ha of haymakings and pastures. These settlements are registered to have the highest  $^{137}\text{Cs}$  content in agricultural products. It can exceed by tens times the standards of SANPIN

2.3.2.1078-01 by milk and by three-four times — by beef. Similar problems exist in 23 collective farms where the fodder and cattle breed production appropriate to the standards is impossible without protective measures. Excess in the SANPIN 2.3.2.1078-01 standards in 11 farms will be long-term; moreover, more than half of the milk produced will not meet the SANPIN requirements. The forecast of the situation shows that the milk production appropriate to the standards will be impossible until 2025–2030.

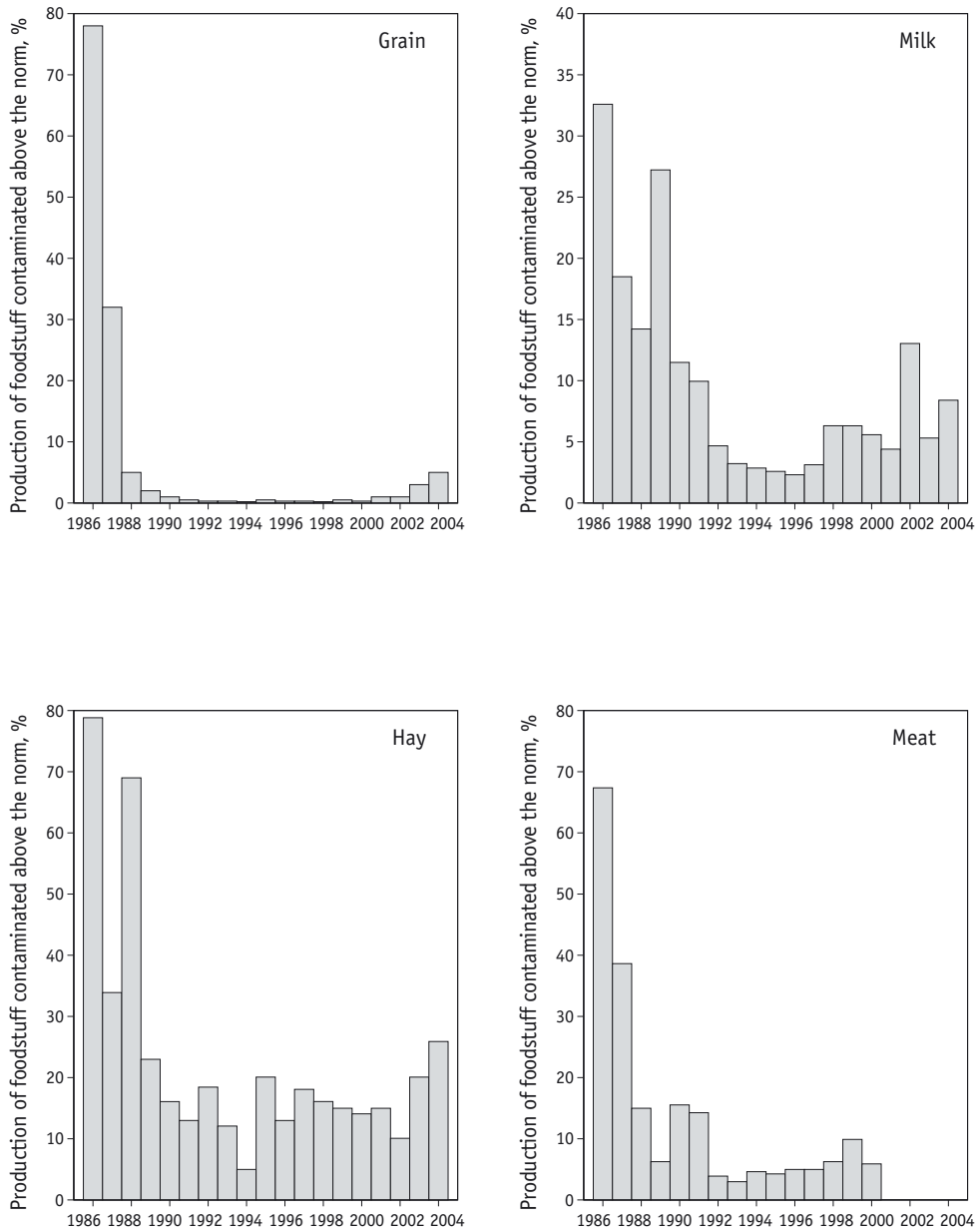


Fig. 5.1. Reduction in production of the foodstuff contaminated above the norm in the contaminated districts of the Bryansk region in 1986–2004

Table 5.5.

**Factors that contribute to reduction of  $^{137}\text{Cs}$  content in agricultural production**

Factors	Regions of intensive countermeasures (Bryansk region)		Regions of limited countermeasures (Kaluga region)	
	Milk/Meat	Potatoes/Grain	Milk/Meat	Potatoes/Grain
Natural biogeochemical processes	0.33	0.36	0.60	0.73
Countermeasures	0.61	0.57	0.28	0.12
Radioactive decay	0.06	0.07	0.12	0.15

In forestry, the system of running the forestry activity under conditions of large-scale contamination of forest resources also has been developed and is under way. Its main goals are health protection for the forestry workers and the public as well as sustainable management of forests under conditions of radioactive contamination of forest resources.

The system of protective measures in forestry is based on the principles of regulation, optimization and justification of radiation safety. By their nature or efficiency, the countermeasures can be divided into six groups, namely: organizational-technical, technological, restrictive, information, social-economic, and preventive.

The basic protective measures include:

- Organization of the radiation control system in the structure of forestry authorities of all levels;
- Terrestrial quarterly radiation inspection of forestry lands along with the cartography of soil contamination density and radioactive zones;
- Regulation of forestry actions by zones of contamination;
- Control of radionuclide content in forest resources;
- Radiation monitoring of forest resources;
- Control over radiation safety of working conditions;
- Regulation of radionuclide content in forest resources;
- Use of forestry technologies that involve few people;
- Maximum labour mechanization that provides decrease in the number of irradiated persons; and arrangements for the regulation of forestry labour.

Of special value are the information countermeasures that cover research; preparation of and improvement in professional skills of forestry workers; keeping the forestry experts and the public informed about the radiation status of forest resources; as well as creation of electronic thematic maps or schemes reflecting the levels of radionuclide content in forest resources.

The scale of radioactive contamination and the dynamics of its change predetermine the status of long-term protective actions. The experience in remediation of the lands contaminated by radionuclides shows that the efficiency of protective measures in forestry is defined to a considerable extent by the level of material- technical and scientifically-methodical equipping.



### 5.3. Social and Economic Development of Contaminated Areas

#### 5.3.1 Dynamics of Economic Development in Contaminated Areas

The Chernobyl accident and the measures on its elimination have entailed evident changes in the economy and social life of the most contaminated areas. Negative consequences are more apparent in the agrarian sector, the basis of local economy.

The Southwest districts of the Bryansk region turned out to be the most affected by the accident. Low agricultural productivity of poor soils and difficulties in producing pure products without the use of special protective measures were the objective reasons for the region and its inhabitants to face unfavourable economic conditions.

During the first period up to 1993, the state helped the collective and state farms to retain their production potential due to implementation of scale protective actions in agriculture. The protective actions brought good results in obtaining pure production and made it possible to increase the efficiency of agriculture. Considerable investments in this sector as well as the construction restricted to a certain extent the downswing that had started since the 1990s. As soon as the funding of federal target programs cut down abruptly, negative processes in agriculture of the contaminated areas increased in comparison with other regions (Table 5.6).

Table 5.6

#### Indices of Agricultural Changes in the Bryansk Region and its Southwest Districts During 1990–2002

	% Indices, as compared to the year 1990					
	Milk sale		Grain sale		Potatoes sale	
	1995	2002	1995	2002	1995	2002
Bryansk region	40.1	24.2	63.1	58.9	9.9	4.8
Southwest districts	33.6	19.0	51.2	40.7	7.7	3.9

When supporting the collective farms and when limiting the production of the private sector during the first period, the state actually reproduced the Soviet economic model. When the model was replaced by the market laws, the rural population from the most contaminated areas could not take advantage of the situation due to the fact that it was impossible to produce the products appropriate to the standards.

Negative demography development had a major impact on the economy of Southwest districts. It was, first, stipulated by the relocation program for the residents living in the most contaminated areas (above 56,000 people during 1986-2004) (Fig. 5.2), as well as by its nature, since mainly young families and experts left. As the result, an outflow of the population capable of working and that of the qualified resources occurred, while those who remained were relatively old. At present, the share of pensioners in the Southwest districts is by 50 % higher than on average in Russia.

Overall, the economic situation in the Southwest districts differed by higher rates of decrease in the basic social and economic indices, as compared to the Bryansk region on average. The average monthly salary of those involved in the economy in 1995 made up 66 % of the average regional and reduced to 57 % in the years that followed. The rate of unem-

ployment in the Southwest districts during 1995–2002 remained almost by 15 % higher than in the entire region. The current investments into capital assets and the volumes of retail sale per capita in these districts are almost twice below the average regional indices (See Fig. 5.3).

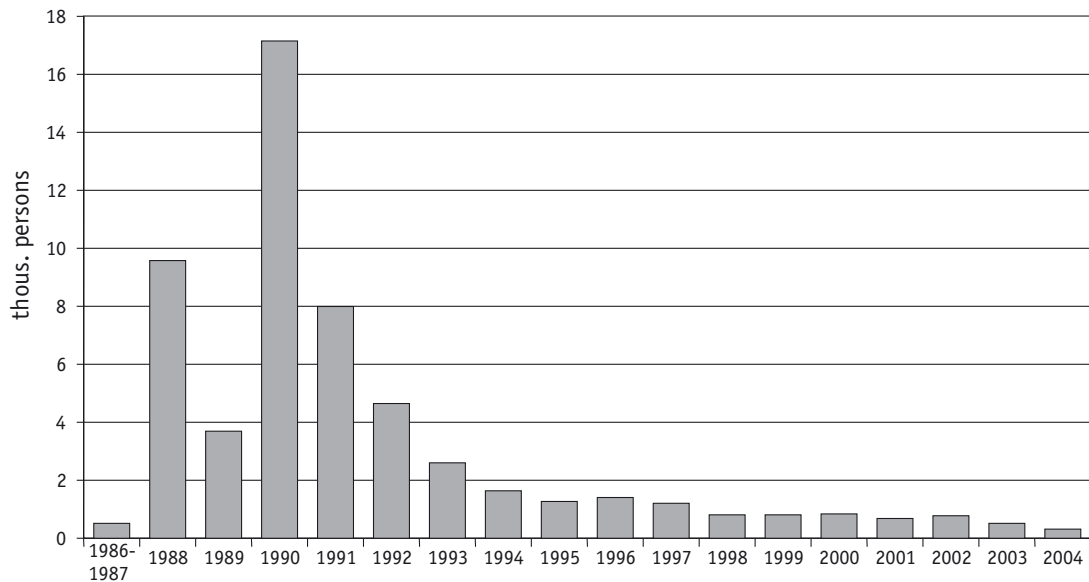


Fig. 5.2. Resettlement dynamics of the population residing in the most contaminated territories of the Bryansk region (south-west districts)

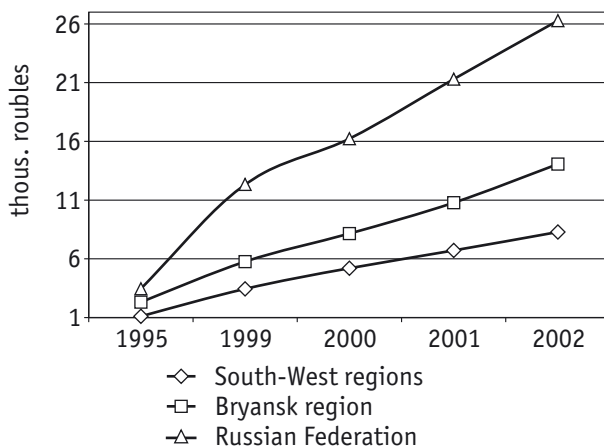


Fig. 5.3. Per capita retail sale in current prices

The main problem of the regions suffered from radioactive contamination is poverty deeply rooted in the structure of their economy. Low labour productivity in agriculture, the lack of work among townsmen, and an outflow of the resources result in an extremely low level of incomes. In its turn, the low incomes are a main impediment on the way to development of local economy in new market conditions.

### 5.3.2. Social and Economic Remediation of Contaminated Areas

The main trend in social and economic rehabilitation of the public and remediation of the areas was the construction of social infrastructure and that of dwelling houses for the resettlers. During 1992–2005, more than 80 % of federal funds was spent to implement the program actions. The total amount of funding for capital investments during the above period made up 3,059,500 roubles (in the prices of the corresponding years), i.e. nearly 1.6 billion USD. The greatest amounts for the activities on mitigation of the Chernobyl consequences were obtained

in 1992–1996, namely 95 % of all federal funds secured in 1992–2005. Table 5.7 displays the data on commissioning of the sites of social and economic infrastructure.

Table 5.7.

**Commissioning of Sites of Social Infrastructure in 1992–2005**

Year	Dwelling, thous. m <sup>2</sup>	Infant schools, seats	Schools, seats	Hospitals, beds	Polyclinics, visits per shift	Clubs and palaces of culture, seats	Gas Networks, km
1992	648.9	1 330	9 243	310	2 595	1 200	
1993	305.7	740	2 814	205	1 735	1 100	
1994	204.6	570	2 085	237	255	1 200	
1995	77.27	210	1 681	60	30		
1996	22.0	195	316	50	40	80	
1997	15.4	420	357		20		367.55
1998	10.2		547				201.0
1999	16.1		395	82		380	209.3
2000	13.96		395	287	320		57.15
2001	17.51		350	56			56.1
2002	7.3	12	258				42.6
2003	13.4	280	477				31.6
2004	6.4		504	89			52.3
2005	8.4		1 050	82			63.4
<b>Bcero:</b>	<b>1 367.14</b>	<b>3 757</b>	<b>20 472</b>	<b>1 458</b>	<b>4 995</b>	<b>3 960</b>	<b>1 081</b>

The most considerable part of funds was forwarded to the Bryansk region. 52.7 % of the total amount of federal funds was secured to finance the programs in 1992-2005. It should be mentioned that no other region of Russia received so considerable capital investments on social needs from the federal budget during those years. In 1992, the federal funds for mitigation of the Chernobyl consequences in the Bryansk region exceeded the amount of the regional budget.

The investment projects had an evident impact on the social sphere of contaminated areas as new dwellings, sites of social infrastructure, and communications were constructed. At the same time, the approach to social and economic rehabilitation was rather social than economic. The funds were invested to improve social infrastructure but it did not mean automatic improvement of the economic situation or increase in public income. That only created some prerequisites to achieve the purpose, though they were few to increase economic activity of the public or stimulate the development of local economy.

The approaches to social and economic rehabilitation implemented in the early 1990s were typical of the planned economy. Large volumes of uncompleted construction in the contaminated areas may exemplify the fact. As for considerable volumes of the dwelling houses under construction, they also were negative to some extent as the dwelling was mainly designed for the resettlers, rather than for the residents living on the contaminated lands. No attention was given to integrated solving of the issues of social and economic rehabilitation. For example, the required production and social sites did not exist for the

resettlers in the localities. In practice, the development of huge volumes of budget resources was of low efficiency and did not bring the desired improvement in living standards of the public.

Since 1994, negative processes in the economy of Russia have impacted the program funding. The limited opportunities of the federal budget did not make it possible to run the remediation actions in the same volumes. At present, the federal funds actually secured for the Bryansk region under the target program «Mitigation of Consequences of Radiological Emergencies for the period until 2010» make up about 2 % of the local budget. These funds are invested into single sites and that cannot solve the task of economic revival of the most contaminated areas.

At the same time, the experience shows that the lack of financial resources is not the sole issue that impedes the economic development of contaminated areas. New economic projects cannot be fully implemented without enterprising people in places or without preparation of management personnel.

### *5.3.3. Update of Guiding Lines*

The items of economic development of the contaminated areas under new market conditions have long remained unattended. Today, the economic items rank first and predetermine a package of problems the residents from the contaminated areas run into every day. In this connection, the current subprogram requires significant update. During enhancement of the state management system, it is important to increase the efficiency of mechanisms used to solve the key objectives of the program.

A need to update the federal target program is stipulated by changes in the RF legislation with regard to the powers of the authorities, the RF subjects, and local governments. Also, it is stipulated by the fact that the obligations of federal budget in part of medical or accomodation provision are fixed by law. Therefore the priorities, the basic trends and the key actions of the federal program require significant update.

Tackling the items of social and economic rehabilitation of the most contaminated areas within the framework of the second milestone of the program for the years 2007-2010 will be provided by the following main trends:

- Creation of the infrastructure (the gas and water supply systems) essential for provision of safe life activity of the public living on the lands affected by radioactive contamination;
- Creation of the conditions for safe use of the resouces of area development (agricultural and forestry lands in the districts suffered from radiation effects).

## **5.4. Social and Psychological Rehabilitation**

By their coverage and public significance, social and psychological consequences of the accident multiply exceed its radiological or, probably, economic effects. The scale of social and psychological consequences can be only partly explained by heaviness of the catastrophe occurred. To a major extent, it is public response to those unjustified administrative decisions that stipulated the involvement of millions of people into the post-accident situation.

A need for social and psychological rehabilitation of the public living in the contaminated areas and of the liquidators was appreciated in the first years. In 1990, the Decrees of the USSR/ RSFSR Supreme Council stated a complicated social and psychological situation in the contaminated areas; insufficient public communication; a loss of trust in local/ central authorities; and a need to solve these issues.

However in 1991, the decisions that long defined the scale of social and psychological consequences of the accident were made. The citizens from many regions of the Russian Federation were acknowledged by law as affected by radiation or the radiation risk, owing to their residence and work on the lands of radioactive contamination. Millions rather than thousands of people began to associate themselves with «the Chernobyl victims» and to fear radiation and its health effects.

As a result, public concern about the accident consequences has increased with time. According to the all-Russian poll run by the Fund «Public Opinion» in February 2006, only 10 % of the public think the consequences to be mitigated; 83 % believe the effects to continue to harm human health and the environment.

The importance of social and psychological consequences of the accident is especially emphasized in the Chernobyl Forum’s report dedicated to the health items. The impact on public mental health associated with the accident and its consequences is acknowledged to be the most serious issue of public health. Moreover, such concern about eventual health effects may extend to cover wider public segments outside the contaminated areas.

The majority of sociological research run in Russia has mentioned the above fact. It is worthy to say that both in the early 1990s and today, the residents from poorly contaminated areas with the privileged social and economic status were and are mostly concerned by the issue, as compared to the resettlers.

At the same time, it is necessary to emphasize that economic difficulties (such as low living standards, unemployment, and price increase) trouble people most nowadays. At this background, the Chernobyl benefits and the chance to be devoid of them, rather than radiation effects, serve the reason for this concern. The Chernobyl Forum presents the data of the poll run in Russia for the residents of the four most contaminated areas. Its material shows that social and economic issues are more valued than the level of radioactive contamination.

<i>What troubles you most today?</i>				
Health	Living Standards	Benefits	Radiation	Unemployment
514	375	204	128	115
The results of the poll run in Russia in 2003. 748 respondents were involved with an opportunity for them to give several answers				

Social and psychological rehabilitation of the public was long associated with information work and consulting services. With this aim in view, the centers for social and psychological rehabilitation of different public groups were created in Russia supported by the UNESCO-Chernobyl program. Similar centers or their branches in the organizations of social public service were established through support of EMERCOM of Russia. Elaboration

of special information material on various aspects of the accident consequences was performed within the scope of state mitigation programs and a number of international projects.

Today, effective social and psychological rehabilitation cannot be based solely on the information about radiological aspects of the accident. New forms are required to keep the public informed as to the practical items dealing with medical education, the impact of various risk factors on health, and healthy life style.

Increase in the significance of economic priorities of the rehabilitation programs also should be taken into account. Today's poverty, rather than radiation, is the basic problem of the residents from contaminated areas. In this connection, implementation of the measures on social and economic rehabilitation as well as the information and educational programs aimed to stimulate local economic initiatives and public employment will simultaneously serve the purpose of reducing social and psychological tension in the contaminated areas.

### ***5.5. Information and Analytical Provision of Activities***

In 1990, the USSR GosComChernobyl initiated the activities on system analysis of Chernobyl consequences and information-and-analytical provision of the works under the state programs. The Nuclear Safety Institute (IBRAE) created within the system of the Academy of Sciences in 1988 and aimed to systematically analyze fundamental safety issues, including the investigation of radiological consequences of heavy accidents, has become the leading organization in this trend. The IBRAE RAS gathers and generalizes the data obtained from the enterprises/ organizations/ services with regard to environmental contamination, agricultural products/ foodstuffs, public exposure doses, medical-and-population and social-and-economic characteristics of the contaminated areas. Overall information on the issue enters the Central Bank of Generalized Data (CBGD). The scheme represents the CBGD basic sections.

For example, the CBGD databank on the radiation-and-hygienic status in localities covers the information on all settlements envisaged by the lists that the RF Government has approved. More than 30 indices are available for every locality describing its administrative and territorial belonging, its administrative and economic importance, its reference to the contaminated areas in compliance with the governmental decisions approved. Besides, the information exists as to the number of residents since 1986 (the available data on the number of men and women, or children if it is the case of the most contaminated areas). For such areas, one may obtain the information on soil characteristics in the site of locality that are important for description of radionuclide migration.

Another example is the databank on demography that contains information on the reason-related mortality in Russia's areas affected by radionuclide contamination resulted from the Chernobyl accident, as well as in other RF subjects. The database covers information on the number of people who died from different reasons; it is the 5-year breakdown by the years of life. 18 classes of death reasons are represented. The death rate from neoplasms is detailed with respect to tumour localizations (23 single ones).

	Geographical attachment		Radioactive contamination		Medical statistics		Implementation of the state program	
	Economic characteristics	Demography	Exposure doses	Chemical-toxicological contamination	Social care	Social psychology		
Cities, towns settlements	■	■	■	■	■	■	■	■
Agricultural lands	■	■	■	■	■			■
Forests	■	■	■	■				■
Atmosphere, water, and soil	■		■	■	■			
Districts	■	■	■	■	■	■	■	■
Regions	■	■	■	■	■	■	■	■
Zones	■	■	■	■	■	■	■	■
Personal data (liquidators and other)	■	■	■	■	■	■	■	■

■ Data available      ■ Database filling

*Status of the CBGD databases*

On the basis of the central bank information the following is performed;

- Information and analytical support of EMERCOM of Russia in implementation of the state programs for consequence mitigation;
- Provision of local authorities with information systems and databases on the issue;
- Provision of research organizations with geoinformation systems and databases;
- Preparation of information and analytical material for the public.



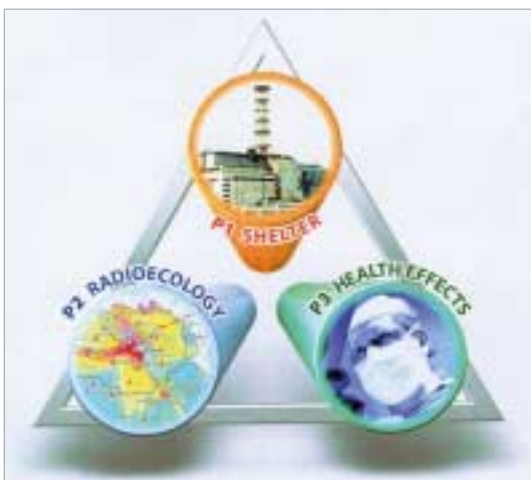
It has become evident with time that improvement in public communication is one of main trends of the activity. Recently, practical work in this direction has been carried out within the scope of the state programs and international projects.

In 1998, the IBRAE RAS-based National Chernobyl information center and a regional network that comprised the three Russian centers for social and psychological rehabilitation, as well as the publishing house «Russian Chernobyl» were established on the initiative of

EMERCOM of Russia. Within the framework of the TESIS information projects, Russian experts created the educational multimedia program titled «Sherlok Holmes. The Radiation Case» for a secondary school and that of «Chernobyl in 3D» for institutes of higher education. The both became prize-winners in the professional contest of Russian multimedia CD-ROM «Content-2000» and «Content-2002». The combination of state-of-the-art computer technologies and literary technique has made the science intensive information quite attractive to the youth audience, having provided wide popularity to these programs not only in the contaminated areas but also all over the country.

Since 2002, the IBRAE RAS-based Russian-Byelorussian information center (RBIC) has been functioning in compliance with «The 2002–2005 Program for Joint Activity on Mitigation of Chernobyl Consequences within the Framework of the Federal State». Its aim is the information and analytical support for implementation of the Program actions; to elaborate and run a common information policy with regard to Chernobyl issues within the scope of the Federal State; to minimize social and psychological consequences of the Chernobyl accident; and to provide high efficiency for the entire complex of program actions by way of improving public perception and keeping the public informed. The RBIC activity also is supported by the Institute of Radiology of Byelorussia's ComChernobyl and by the Geoinformation Systems Facility of the Byelorussian Academy of Sciences. Within the scope of this activity, the CBGD-based Integrated Russian-Byelorussian databank on basic aspects of the Chernobyl consequences has been created and is freely accessed in the Internet network (<http://rbic.ibrae.ru/RBIC/>). The RBIC has compiled and published under a joint plan above two tens of books/ brochures addressed both to experts and wide public segments. Apart from it, regular workshops/ trainings aimed to assist in arranging public work are conducted.

The important element of information and analytical provision for the activities is consideration of scientific and technical experience accumulated in the world and by international organizations, such as IAEA/ UNESCO/ UNICEF/ WHO, etc. The International Chernobyl Research Network project (ICRIN) should play a significant role in facilitating the access to information resources. Since 2003, the Russian party has been actively involved in the project activities.



Among other international data accumulation/integration projects recently implemented, it is necessary to mention those within the scope of the French-German initiative on Chernobyl. The activities ran on the basis of the International Chernobyl center by efforts of more than 20 organizations from Byelorussia/ Russia/ Ukraine/ Germany/ France. The work covered the three directions: safety of the Shelter, radioecological consequences and health effects. The main result of the French-German initiative has become the database that comprises detailed, reliable and objec-

tive information on the Chernobyl consequences. Such information is essential for people in-



volved in the decision-making as to action planning, public communication and further scientific work. Besides, the accumulated information will help the international community to make use of the Chernobyl experience in the case of nuclear and radiological incidents and prevent similar accidents in future.

During 2003–2005, scientific cooperation and consolidation of scientific results was performed mainly within the scope of the Chernobyl forum held under the IAEA initiative and supported by other UN organizations. The Russian delegation headed by EMERCOM of Russia's deputy minister N.V.Gerasimova was constantly involved in the working sessions of the Chernobyl forum where the results of the activities of the forum's expert groups on medical consequences of the accident and environmental impacts were discussed. The Russian delegation was the most representative at the September, 2005 final forum conference: the leaders of all main trends of the «Chernobyl science» gathered there.

## 6. DEVELOPMENT OF RF LEGISLATIVE BASIS IN THE FIELD OF SOCIAL PROTECTION OF CITIZENS SUFFERED FROM CHERNOBYL CATASTROPHE

Protective and remediation actions, assistance to the sufferers, including the payment of compensations and provision of benefits for the risk of eventual damage to the health of citizens started to be implemented immediately after the accident in compliance with the special decrees of the federal and Russian governments.

Afterwards, the legal standards developed on the basis of the “Concept for Public Residence in the Areas Affected by the Chernobyl Accident” [24]. The Concept’s aim was defined as formulation of principles and criteria to justify practical measures for maximum reduction of eventual negative health effects of the accident and for compensation of the damage caused.

The Concept was aimed at optimizing protective measures based on the dose criterion. Eventual exposure doses were to define the intervention levels. At the same time, the Concept put the accent on a social and psychological factor along with the radiation aspect. It outlined that the actions for the dose load reduction should be aimed at slackening of social and psychological tension/stresses among the public. Moreover, it stated that social and psychological consequences might have greater negative health effects than the radiological factor itself.

**The Concept proclaimed that** *“the individual residing in the radio-contaminated area or who lived there no less than the minimum term established has the right to reparation of damages as benefits/compensations/guarantees, as well as the systems of social and medical provision in the order envisaged by the legislation” (Item 5). It was assumed (Item 6) that “the basic index for decision-making as to the arrangements of protective actions, their nature and scale, as well as indemnification is the exposure dose caused by radioactivity as a result of the accident at the ChNPP”.*

Extra excess public exposure within the 1mSv annual effective equivalent dose was assumed to be quite permissible. This exposure level does not need any intervention, same as the living conditions or labour activity in the appropriate areas do not require any restrictions.

At higher levels, a complex of protective measures aimed to reduce the dose load was envisaged. It is important to mention that their optimization should take into account maximum reduction of restrictions that infringe the accustomed life style. Apart from radiation protection, the protective measures should comprise as follows:

- Improved medical and sanitary public service (the groups of increased risk require special attention);
- Provision of adequate nourishment;
- Measures to reduce social and psychological tension; and
- Social and economic measures (compensations/ benefits/ guarantees).

The impact of the Chernobyl accident should be considered jointly with other risk factors (chemical pollution, endemic or biochemical peculiarities of the districts, etc.).

Under the influence of public opinion, the Concept's provisions were deformed in the RF basic law No.1244-1 dt. May 15, 1991. "On Social Protection of the Citizens Affected by Radiation as a Result of the Chernobyl Catastrophe".

For instance, both the dose loads indices and the characteristics of contamination density were simultaneously used at zoning. That resulted in ambiguous interpretation of the Law and increased social tension in a number of regions. Further, when defining the status of the citizens who might be acknowledged as sufferers from radiation, the people involved in the elimination of accident consequences within the Exclusion zone also were related to the above mentioned category. The wording that took into account the term of stay and the obtained dose value was deleted. It was replaced by allocation of the liquidators into those of the years 1986–1987 and 1988–1990. The decision on social guarantees for the participants in the elimination of accident consequences was simplified. Everyone who had spent at least several hours in the 30-km zone before 1990 obtained the status of liquidator. The evident simplification of this criterion sufficient in term and duration of stay entailed considerable economic damage to the state and led to the development of a whole number of negative social processes among the liquidators. According to the data of the Russian State medical and dosimetry register, only part of the year 1986–1987 liquidators relates to the group of increased risk (See Section 4.2).

The Law envisaged benefits and compensations to the citizens residing in radio-contaminated areas depending on the zones of radioactive contamination within the boundaries of which the areas were located.

In 1992–2003, the Chernobyl law was amended and supplemented due to specification of the categories of sufferers and their benefits/ compensations provided. For instance, the February 12, 2001 Federal Law No. 5 «On Introduction of Amendments and Supplements into the RF Law "On Social Protection of the Citizens Affected by Radiation as a Result of the Chernobyl Catastrophe"» adopted by the State Duma on December 21, 2000 introduces new provisions aimed to increase addressability and enhance the mechanism of realizing social benefits and compensations. In particular, the law envisages that annual indemnification increase should be proportional to increase in the living wage all over Russia.

In 1995, the RCRP "Concept for Radition, Medical and Social Protection and Rehabilitation of the RF Population Suffered from Emergency Exposure" was adopted. It was recommended by the RF Government to be used in developing normative and legislative documents and target programs in the field of social protection of the RF citizens affected by radiation.

Within the scope of this concept, the irradiated person is acknowledged to be an individual whose effective dose of acute exposure resulting from radiation accident exceeds 50 mSv or whose accumulated effective dose of chronic exposure is more than 70 mSv. The sufferer is acknowledged to be an individual with deteministic effects or other diseases developed as a result of radiation accident and with respect of which the causation with emergency exposure or other emergency events has been officially revealed.

Therefore, the document certifies the fact that the exposure dose is an objective quantitative index of actual radiological damage to the residents of radio-contaminated areas. The criterion for selectiong those or other intervention levels aimed to protect the public is a nu-

merical value of the annual dose versus the values of 1.5 mSv/year and 20 mSv/year established by the Concept.

In 1991–2004, the state spent above 65 billions of roubles (in prices of the appropriate years) to fund the benefits and compensations.

The analysis with regard to the experience of practical implementation demonstrates distinctly a low level of justification for benefit/compensation expenditures associated allegedly with indemnification of the damage. It is revealed when comparing (in value terms) the volume of actual payment of compensations and provision of benefits with the objective estimates of health effects indirectly associated with the collective exposure dose. A grave source of the errors was the replacement of a criterion characterizing eventual health damage (the exposure dose) for an environmental criterion as an estimate of average density of Cs-137-contaminated area of the locality.

Validation of the Chernobyl law happened to be a precedent that made it possible to raise a question as to social protection of the citizens suffered from other radiological emergencies or during nuclear tests, and such laws were adopted.

Federal Law No.122 dt. August 22, 2004 «On Introduction of Amendments and Supplements to the RF Legislative Documents and on Acknowledgement of Some of the RF Legislative Acts as Invalid due to Adoption of the Federal Law “On Introduction of Amendments and Supplements to the FL “On General Principles of Arranging the Legislative (Representative) or Executive State Authorities of the RF Subjects” and that “On General Principles of Arranging the Local Self-Government in the Russian Federation”» came into force on January 1, 2005. The Law defines the current state policy in the field of social protection of the RF citizens affected by adverse factors as a result of the Chernobyl catastrophe or involved in the elimination of accident consequences.

FL No. 122 dt. August 22, 2004 has changed significantly the social legislation that regulated the items of social protection for the citizens suffered from radiation.

The benefits/compensations provided earlier to the citizens were specified; the standards long unused or outdated were deleted, and a new notion, such as the measures of social support, was introduced into the legislation.

The system of social benefits has radically changed since January 1, 2005. Many natural benefits were replaced by monthly pecuniary payments. The replacement has both a positive and a negative aspects. On the one hand, “live money” is spent on any other needs, as compared to the natural benefit being of strict target nature when nobody can make use of it, except for the one to whom it is addressed. On the other hand, the amounts of pecuniary payments do not compensate to the full extent the natural services abolished. That makes the liquidators’ financial position worse, as unequal demand of the citizens in natural services predefines, in essence, the impossibility for them to be replaced with equal pecuniary payments.

These state measures were perceived as equivocal by the liquidators and the residents of radio-contaminated areas. Therefore, much in this direction has to be clarified and made to guarantee and provide actual realization of legal rights for the liquidators and all citizens of Russia suffered from the Chernobyl accident or other radiological emergencies.

The change in the federal law has required from the RF Government to create a practically new mechanism for the implementation of legislative standards amended.

To create the mechanism for realization of social protection measures established by FL No.122 dt. August 22, 2004 for the citizens affected by radiation, EMERCOM of Russia jointly with concerned ministries and agencies elaborated in 2004–2005 the drafts for appropriate decisions of the RF Government.

To provide implementation of the above FL, the RF Government has issued the following decrees:

- No.817 dt. December 21, 2004 “On Approval of the List of Diseases Giving the Affected Invalids the Right to Extra Living Space”;
- No.818 dt. December 21, 2004 “On Federal Executive Bodies Authorized to Define the Order and Conditions for Registration and Issue of the Certificates for Single Categories of the Citizens from among the Number of Individuals Affected by Radiation as a Result of the Chernobyl Catastrophe, as well as the Citizens from the Teams of Special Risk” (amended on June 20, 2005);
- No. 869 dt. December 29, 2004 “On Approval of Procedures for Repayment to the Citizens of Material Damage Compensations in connection with the Loss of Property Resulted from the Chernobyl Catastrophe and On Assessment Standards to be used obligatorily by the Subjects of Evaluative Activity in Defining the Cost of Constructions and Property, taking into account the Extent of Their Radioactive Contamination Resulted from the Chernobyl Accident”;
- No. 864 dt. December 29, 2004 “On Funding the State Social Assistance as a Set of Social Services to the Citizens and On Fixing the Price for its Provision to the Individuals Affected by Radiation as a result of the Chernobyl Accident and due to Nuclear Tests in the Semipalatinsk Testing Area, as well as to the Categories of Citizens Equated with Them” (amended on March 23/ June 30/ August 2/ December 28, 2005);
- No. 866 dt. December 29, 2004 “On Procedures for Federal Provision of Accommodation for the Citizens Affected by Radiation as a result of the Chernobyl Catastrophe and by the Accident at the Mayak Facility, as well as for the Individuals Equated with them Who Are in Need of Improved Living Conditions”;
- No. 907 dt. December 31, 2004 “On Social Support for the Citizens Affected by Radiation as a result of the Chernobyl Catastrophe” (amended on June 16, 2005).

Further development of the Law should be based on the use of dose criteria, when defining the measures of social support for the citizens affected by radiation as a result of the Chernobyl accident. The Law should be developed in compliance with the “Concept for Radiation, Medical and Social Protection and Rehabilitation of the RF Population Suffered from Emergency Exposure” and the Radiation Safety Standards (RSS-99). The latter is a fundamental document that regulates the requirements of Federal Law No.3 “On Public Radiation Safety” dt. January 9, 1996 in the form of basic dose limits; permissible impacts of ionizing radiation; and other requirements with regard to human exposure restriction.

## 7. CURRENT STATUS OF NUCLEAR AND RADIATION SAFETY IN THE RUSSIAN FEDERATION

### *7.1. State Policy in the Field of Nuclear and Radiation Safety*

The aim, priorities, basic principles and objectives of the state policy in the field of nuclear and radiation safety of the Russian Federation, as well as the trends in program-and-target planning and management in this area are defined by the “State Policy Fundamentals for the RF Nuclear and Radiation Safety Provision for the Period until 2010 and Further Perspective” and approved by RF President V.V.Putin by order No. 2196 dt. December 4, 2003 (referred to hereafter as “State Policy Fundamentals”).

The State Policy Fundamentals state that the emergencies associated with nuclear- and radiation-hazard sites, including nuclear weapons and their components, nuclear material, radioactive substances/ waste, and sources of ionizing radiation, as well as having long-term negative effects represent a major threat to national safety and social and economic development of the Russian Federation.

The Fundamentals consider the following as the main factors defining the state policy in nuclear and radiation safety:

- Essential processing of a great number of nuclear material, fuel assemblies of nuclear reactors, radioactive waste accumulated during creation of nuclear weapons and production of nuclear material, operation of nuclear power facilities and nuclear industry, that of nuclear submarines, surface vessels and vessels with nuclear installations, and as a result of other kinds of activity in the field of nuclear power use in the Russian Federation;
- Essential remediation for the RF areas with the adverse radiation status resulted from the accidents in the sites of nuclear power use, nuclear tests, peaceful nuclear explosions;
- Significant increase in the scale of international cooperation in the field of nuclear and radiation safety; a need to increase the efficiency of this cooperation.
- The basic principles of the state policy in nuclear and radiation safety provision are as follows:
  - Adherence to the RF legislation and observation of international agreements, treaties and conventions where the Russian Federation is the member-state;
  - Provision for nuclear and radiation safety as an indispensable condition for performance of any activity in the field of nuclear power;
  - Implementation of the socially acceptable risk concept aimed to minimize nuclear and radiation risks (as components of a cumulative human-induced risk), including maintenance at possible low level (taking into account economic and social factors) of permissible individual exposure doses and decrease in the number of irradiated individuals, when using nuclear power and sources of ionizing radiation;
  - State-guaranteed adherence to permissible limits of radiation obtained by citizens from all sources of ionizing radiation; prohibition of all kinds of activity in the field of nuclear power where the positive result does not compensate a risk of eventual harm;

- Available information as to the status of nuclear and radiation safety, provided that the RF legislation is observed in the area of state secret protection;
- Permanent preparedness of the forces/facilities for the elimination of consequences of eventual emergencies associated with nuclear power.

The State Policy Fundamentals are implemented stage-by stage. In the years 2006-2010, actions of the second milestone are performed.

## ***7.2. Federal Target Programs***

Federal Target Programs (FTP) are one the basic mechanisms of implementation of the State Policy Fundamentals.

Apart from the FTP “Mitigation of Consequences of Radiation Accidents for the Period until 2010”, other FTPs covering the actions on nuclear and radiation safety have been recently in process in the Russian Federation.

The FTP “Russia’s Nuclear and Radiation Safety for the Years 2000–2006” (approved by the RF Governmental Decree No.149 dt. February 22, 2000; amended by the the RF Governmental Decree No.371 dt. June 10, 2005 ). The State customer and coordinator- the Federal Agency for Atomic Energy (FAAE).

The FTP “Risk Reduction and Mitigation of Natural and Human-Induced Emergency Consequences in the Russian Federation until the year 2010”. The State customer and coordinator — the RF Ministry for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters (EMERCOM of Russia).

The FTP “Industrial Recycling of Armaments and Military Equipment (2005-2010)”. The State customer and coordinator is the RF Ministry of Industry&Energy (the sub-program “Industrial Decommissioning of Nuclear Submarines, Surface Vessels, Vessels with Nuclear Installations, Vessels of Atomic Technological Service and Remediation of Coastal Technical Bases”. The State customer is FAAE.

The FTP “Energy-Effective Economy for the Years 2002–2005 and for Perspective until the Year 2010”. The State customer and coordinator is the RF Ministry of Industry&Energy (the sub-program “Safety and Nuclear Power Development”). The State customer — FAAE.

Due to implementation of the above programs, first, the FTP “Russia’s Nuclear and Radiation Safety for the Years 2000–2006”, certain results were achieved in the field of nuclear and radiation safety provision, among which the following should be outlined:

- Nuclear and radiation safety of the Russian Federation has been provided recently, owing to observation of permissible operation limits for reactor and other nuclear installations, sources of radiation and storing points, as well as the dose exposure limits for personnel and the levels of permissible environmental radiation effects.
- Great work has been performed to analyze and assess the situation with nuclear and radiation safety provision the results of which were reflected by the State Policy Fundamentals.
- Some state systems of radiation safety provision, such as the system of accounting radioactive substances/waste and the system of automated radiation environment control, have developed to a limited extent.

The objective for rapid development of nuclear power/industry and increase in the share of energy generation by nuclear power stations (NPPs) in Russia makes it essential to speed up significantly the activities on nuclear and radiation safety of the country.

According to the plan of actions on implementation of the first milestone of the State Policy Fundamentals that was approved by the RF Governmental Instruction No. 117 dt. February 3, 2005, Rosatom, other federal executive authorities concerned and the Russian Academy of Sciences (RAS) were assigned to develop proposals as to the FTP concept/draft “Russia’s Nuclear and Radiation Safety for the Years 2007–2010”. At present, the concept draft is developed and is in the process of reconciling with federal executive authorities, as well as the program preparation is under way.

By results of the March 14, 2006 meeting on nuclear power development, the RF President has given instructions to the RF Government to adopt the FTP “Development of Russia’s Atomic Energy and Industrial Complex for the Years 2007–2010 and for Perspective Until 2015” and to envisage that funding for this program be included into the 2007 federal budget project supported by the state in atomic generation (the construction of no less than 2 power units, starting from 2007). Besides, due to termination in 2006 of the term for implementation of the FTP “Russia’s Nuclear and Radiation Safety”, the RF President has assigned the RF Government to envisage in the 2007 federal budget project the funding for the List of actions on nuclear/radiation/environmental safety provision, as well as to approve in the established order the FTP “Nuclear and Radiation Safety Provision for the Year 2008 and for the Period Until 2015” (the list of the RF President’s Assignments No.415 dt. March, 16, 2006).

### ***7.3. Status of Nuclear and Radiation Safety for Nuclear Power and Nuclear Industry***

The basic trend in the activities on nuclear and radiation safety for Russia is the provision of current safe operation of the sites designed to use nuclear power in all milestones of the life cycle and that of functioning of the state systems of safe nuclear power management and safety regulation.

Recently, nuclear and radiation safety has been provided, on the whole, for the current production activity of the facilities. Above 10-15 billion roubles of the facilities’ own means and several billion roubles from foreign funds are annually spent for these purposes. Though, the state means were not actually secured for the elimination of nuclear heritage, the creation of safe sites to store accumulated radioactive waste (RW) and spent nuclear fuel (SNF), the infrastructure of their management, and the creation of state nuclear and radiation safety systems, except for funding the nuclear submarine decommissioning.

The issue of nuclear heritage elimination is complex and multi-pronged and cannot be completely solved within the nearest years due to economic and scientific and technical restrictions.

At present, the accumulated problems and postponed decisions can be briefly outlined in the following way:

- Nuclear- and radiation-hazard sites of Rosatom (4 power units of the NPPs, 10 industrial uranium-and-graphite reactors and above 110 nuclear- and radiation-hazard



sites of other function); those of Rosprom and other agencies (up to 50 sites) have terminated their activity but have not been finally decommissioned. Safety support for these sites in the closedown regime requires the constantly increasing funding.

- State strategic decisions as to the RW/SNF management are lacking.
- Organizational and legal mechanisms for cost- efficient RW management during the current economic activity have not been created.
- Temporary RW repositories are not designed to provide reliable isolation of radioactive waste from the environment during several decades (more than 1,170 storing points). Significant enhancement of current repositories and creation of new points for final isolation of radioactive waste is required.
- Great RW volumes non-isolated from the environment are available, namely: the Techa reservoir cascade, tailing dumps of the nuclear fuel cycle facilities and radio-contaminated areas. Their safety maintenance requires continuous capital inputs.
- Above 15,000 tons of SNF are accumulated. The SNF near-critical filling of repositories at the NPPs with the RBMK/ EGP-6 reactors (the Bilibino NPP) as well as that of the RW plant repositories makes doubtful the provision of their proper safety level.
- The use of radiation-producing equipment in more than 15,000 organizations of different agencies and forms of ownership increases significantly their vulnerability from the standpoint of terrorist threats.
- No legislative/normative/technological solutions have been obtained for remediation of the sites created by nuclear explosive technologies (the sites of peaceful nuclear explosions).

The peculiarity of implementation of the actions on nuclear and radiation safety with regard to solving the accumulated problems is defined by long final liquidation of nuclear- and radiation-hazard sites and by an available potential threat of heavy radioactive contamination of the environment, if the appropriate actions are not taken. The expenditure increase in future periods is inevitable at the lack of scale practical actions for the forthcoming years and at further shift of the nuclear heritage responsibility to succeeding generations. By preliminary estimates, the expenditures may reach 250 billion roubles for the period until 2015 (without consideration of increase in the risks of radiological emergencies). However, the expenses can be reduced to 70–95 billion roubles for the particular period, if intensive activities are developed.

Owing to historical grounds, the accumulative funds for decommissioning and RW/SNF management, as well as the appropriate mechanisms of their forming have not been created in the Russian Federation until the present. The available RF Governmental Decrees (No. 68 dt. January 30, 2002 for the NPPs and No. 576 dt. September 21, 2005 for other facilities of nuclear industry) are not effective enough by a number of reasons and have not served the basis for the activities on elimination of nuclear heritage to the full extent. At the same time, the state specialized financial institutes were created in the 1990s not only in the western countries with similar issues but also in the states of Central and Eastern Europe involved in the operation of nuclear installations built under Soviet (Russian) projects.

When solving scale accumulated problems, the principal item is that of the role of the state and business in the system decision-making as to the SNF/RW management and in de-

velopment of the nuclear and energy complex. The basic principles for solving the RW/SNF issue may become as follows:

- The current effective economic activity in the field of nuclear power should provide an opportunity for complex solving of all the items of safe RW/SNF management, including geological isolation of high-level waste.
- The subjects of economic activity cannot be entrusted to the full extent with the task of financial provision for solving the accumulated issues of RW/SNF management. First, it relates to RW/SNF of the defense origin. It is the state that should undertake a considerable part of expenditures.
- The developed perspective sites and the technologies for RW/SNF management should be invariant with regard to the origin of RW/SNF. That will create objective prerequisites for successful cooperation between the state and business.

Strategic items of managing the SNF from NPPs are outside the purely scientific and technical scope and require political decisions. On-going processing of the SNF becomes expedient only in actual closing of the nuclear fuel cycle based on the fast neutron reactors.

By the data of Russia's radiation and hygienic registration certificate, the radiation status in the Russian Federation has remained, on the whole, satisfactory in recent years, except for some excess in the basic limits for four thousand residents from the Musljumovo settlement of the Chelyabinsk region being in the Mayak facility's surveillance zone.

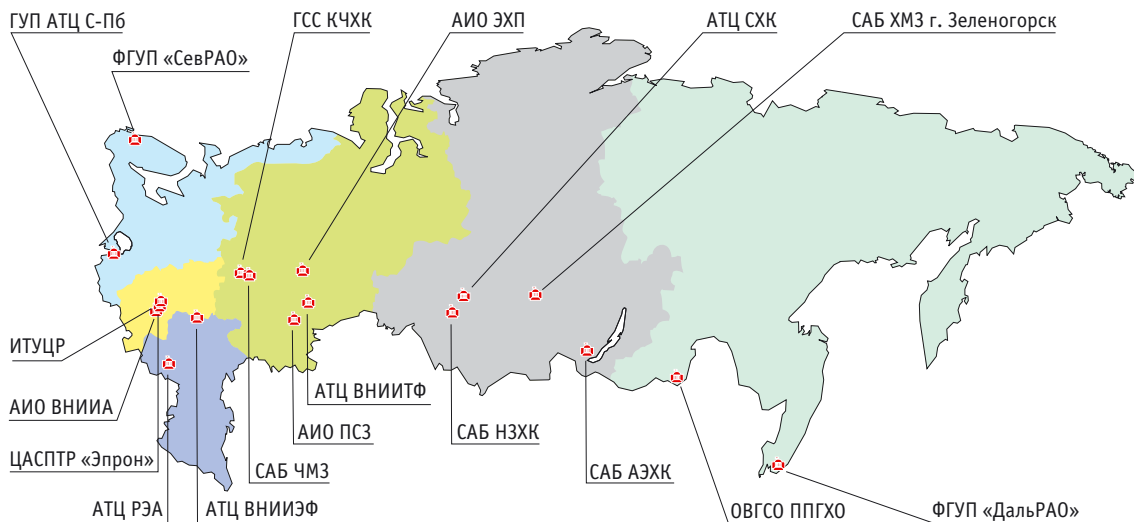
#### ***7.4. Enhancement of the System of Response to Radiological Emergencies***

The important element in the provision of nuclear and radiation safety for the sites of nuclear power is the available reliable and effective system for prevention and elimination of radiological emergencies.

The issue of the accident rate and the emergencies of human-induced nature covers not only nuclear but also all kinds of the activity. To solve it, the Russian system for emergency prevention and actions (RERS) was created in 1992 by the RF Governmental Decree. Afterwards, it was changed in 1995 into the Unified state system for prevention and elimination of emergencies.

Creation and formation of the system of emergency response to radiation incidents fell under the post-Chernobyl period. Just at that time, proceeding from the generalized and in many respects negative experience in elimination of the Chernobyl consequences, the understanding came that regular activity on prevention of natural and human-induced emergencies and an adequate, effective and timely emergency response were the key factors to decrease the risks of adverse public and environmental effects. The greatest efforts to create the state-of-the-art system of emergency response at nuclear- and radiation-hazard sites were made within the scope of development of the Branch Emergency Response System (BERS) of FAAE, the basic federal authority for nuclear power management.

The RERS comprises the authorities, forces and means of the federal executive power; executive authorities of the RF subjects; local self-government and organizations liable for the decision-making in the area of public and territorial protection from emergencies. The RERS activity is aimed to carry out the objectives envisaged by the Federal Law "On Public and Territorial Protection from Natural and Human-Induced Emergencies".



*Allocation of the ERS bodies and teams over the territory of Russia*

EMERCOM of Russia is the RERS permanently operating authority of federal level. The RERS is based on the territorial and production principle and covers the territorial and functional sub-systems. It has five management levels, namely: federal/ inter-regional/ regional/ municipal/ positional. The RERS functional sub-systems are set up by federal executive authorities to arrange the work in the field of public and territorial protection from emergencies within the sphere of authorities' activity. The response to radiological emergencies is the jurisdiction of both the territorial sub-systems of regional/municipal levels and the functional sub-systems of a number of federal executive authorities. The Branch Emergency Prevention and Elimination System (BERS) of the Federal Agency for Atomic Energy (Rosatom) is one of such sub-systems. Rosatom supervises all Russian NPPs, the facilities of nuclear industry and large research centers.

The provision for preparedness to the actions of nuclear authorities/ forces/ facilities aimed to prevent and eliminate the emergencies is one of the most important objectives of Rosatom's BERS. The branch system unites the authorities/forces/means of Rosatom, its corporate structures (the Rosenergoatom Concern, JV "ТВЕЛ", etc), and branch facilities/organizations that are liable for the decision-making as to emergency prevention and elimination.

To arrange and run the activities on localization and elimination of radiological and nuclear emergencies, the Emergency and Rescue Service (ERS) has been created within the BERS. The ERS covers as follows:

- ERS authorities;
- Emergency and Rescue Teams (ERT);
- Research and educational enterprises for rescuer training;
- Organizations producing the emergency and rescue instruments;
- Other teams that provide for solving the ERT objectives.

The ERS forces/facilities comprise the forces of permanent preparedness of federal and branch levels, as well as the ERT substitute facilities.

The federal forces get involved in the elimination of accident consequences not only in Rosatom's sites but also in any sites of nuclear power in the case of radiological emergencies. The federal forces comprise as follows:

- Management of nuclear and radiation safety as the authority of branch ERTs;
- Emergency and technical centers;
- Separate militarized mine-rescue group;
- Emergency and test departments;
- Center of emergency-rescue and underwater technical activities;
- Robotics engineering-technical and training center.

At present, 12 federal teams are covered by the ERS structure.

The forces of permanent preparedness of federal level comprise special emergency teams, unmilitarized teams of civil defense, special teams of NPPs, etc.

In addition, 15 Rosatom's outside ERTs have been established.

Training of professional rescuers plays an important role in nuclear industry. In compliance with the valid legislation, primary and periodical attestations for 12 professional and 14 outside ERTs of Rosatom's facilities have been conducted recently. As of January 1, 2006, the total number of Rosatom's rescuers who had undergone the attestation made up nearly 1,000 people.

Rosatom's NPPs are equipped by the state-of-the-art technical facilities to run the emergency activities. The ERTs have available mobile and portable devices to control the radiation status, mobile devices to diagnose the status of the emergency site, robotics, engineering, facilities to protect personnel, and modern communications.

The BERS important element is the emergency response sub-system at the NPP. Rosenergoatom has established the system for emergency prevention/liquidation during the NPP operation. The system fully corresponds to the normative and legislative documents in the field of emergency response in emergencies at the NPP and is able to perform its objectives to the full extent.

The arrangements for monitoring the safety status and information provision of the response to crisis and emergency incidents is the decisive factor of operative response and the decision-making in management.

Branch safety monitoring is performed by the specialized groups from Rosatom's departments and corporate safety and emergency structures, including Rosatom's Situation-Crisis Center (SCC), Rosenergoatom's Crisis Center, as well as services on duty from Rosatom's central structure. Apart from it, the dispatcher services on duty and the branch crisis centers of the facilities run safety monitoring of site level. Preparedness for the information exchange in extraordinary occurrences in the branch sites is one of the main functions of the above structures.

Operation of the information management system provides permanent preparedness of the BERS forces/means, operative obtaining of the status data from the facilities, timely reports to the management and rendering the assistance to the enterprises, if necessary. The information management system covers as follows:

- Branch Automated Radiation Monitoring System (BARMS);
- Automated Nuclear Transportation Safety System (ATSS);
- Rosatom's communications systems.

The basic body of information provision and the main center of information gathering and information and analytical support for the branch emergency commission and

Rosatom's management is Rosatom's SCC where the on-going 24-hour dispatcher on duty service is organized. The SCC has the available complex of technical facilities for automated processing and display of the delivered information and communications that make it possible to run management of and contacts with both the potentially-hazard facilities and Rosatom's operative group and emergency-rescue teams in the emergency sites.

The System for scientific and technical support of the decision-making with respect to personnel/ public/ environmental protection is available within the BERS structure. The scientific and technical support for protective solutions is performed within the scope of specialized scientific and technical centers created on the base of leading research organizations, such as IBRAE RAS, the Biophysics Institute, VNIIAES and SPA "Taifun". The centers of scientific and technical support are provided with essential program and technical complexes as well as modern communications and data transfer facilities that ensure the opportunity for their direct interaction with Minatom's and Rosenergoatom's centers of emergency management.

To enhance the BERS organization and check up the preparedness of BERS authorities, forces and facilities, the exercises/trainings are annually planned and conducted at the NPPs, the nuclear fuel cycle facilities, and when transporting radioactive material. The exercises involve the forces and facilities of other sub-systems of RERS, EMERCOM of Rus-



*Training of the emergency response teams*

sia, the Ministry of Internal Affairs, the Ministry of Health and Social Development, local and regional authorities, etc. Regular exercises/ trainings are conducted in Rosatom's sites for the purpose of checkup of and increase in the ERT preparedness.

In compliance with the new edition of FL No.68 and the RF Governmental Decree No.335 dt. May 27, 2005, the measures for radiological emergencies of local or regional scale are taken at the local or regional levels. In this connection, creation of the territorial emergency response and monitoring systems as well as provision of local or regional authorities with operative qualified scientific and technical support in radiological emergencies is an extremely actual objective.

Persistent attention to the items of development/enhancement of the emergency response system; realization of practical actions to upgrade it; and implementation of state-of-the-art scientific and technical achievements in the field of safety and emergency technologies have made it possible to provide branch preparedness for prevention and elimination of radiological emergencies.

## CONCLUSIONS

The 20-year period following the Chernobyl catastrophe has made it possible to:

- Give an objective and comprehensive analysis of direct and indirect consequences of the accident;
- Assess the efficiency of decisions made on medical-and-social and radiation protection of the public during different milestones;
- Evaluate the perspectives for mitigation of the accident consequences in various spheres;
- Define how the basic Chernobyl lessons are taken into account in the field of prevention/elimination of emergency consequences at hazardous sites.

As for the basic lessons, it is possible to state that the past twenty years have become those of search and principal significant decisions in the industrial safety provision on the whole and in nuclear and radiation safety in particular. Today, these items are the focus of RF President's attention [25–28]. The Federal Agency for Atomic Energy tackles the most complicated tasks aimed to implement the state policy in the field of nuclear and radiation safety. Safety provision and emergency risk reduction at all stages of the production cycle has become the obligatory initial condition for nuclear power/industry to exist and develop. The current Russian power units correlate by the safety parameters with the values of core damage frequency of  $10^{-4}$  per year of operation recommended by IAEA [29].

Another Chernobyl lesson has been well learned: one should not postpone the decision-making associated with safety provision. The understanding of the fact by the state is reflected in the implementation of the federal target programs entitled “Risk Reduction and Mitigation of Consequences of Natural and Human-Induced Emergencies in the Russian Federation” and “Nuclear and Radiation Safety of Russia”. The latter envisages accelerated solving of the issues associated with the consequences of nuclear arms race as well as the review of strategic items of spent nuclear fuel and radioactive waste management.

### *Prevention and Elimination of Radiological Emergencies*

Chernobyl has entailed considerable review in all nuclear states of the safety principles, the methods of safety justification and the requirements for the scientific basis. After Chernobyl, the normative-and-legal, organizational and technical measures were taken in the Russian Federation to prevent and eliminate radiological emergencies.

By now, the Russian Federation has entered into and ratified the main international conventions on nuclear and radiation safety, notification and assistance in nuclear accidents. Within the Russian normative and legal scope, the basic elements of state safety guarantees for the use of atomic energy are created.

Chernobyl has demonstrated that involvement of the country's top management and qualified scientific resources in a scale radiological emergency is critical for the emergency response. The lesson has served the purpose of making cardinal changes in the arrangements for the emergency response system. Lately, not only the organizational components of the Russian Emergency Response System (RERS) have been fortified but also the appropriate

system of engineering, technical and scientific maintenance has been established. At present, the operators of Russian nuclear power plants (NPPs), such as EMERCOM of Russia's Emergency Management Center, Rosatom's Situation-Crisis Center and Rosenergoatom's Crisis Center, have an opportunity to urgently involve experts from the scientific and technical maintenance centers. The leading research centers obtain overall essential and operative information about the situation from the Automated Radiation Monitoring Systems (ARMS) available at all NPPs and Russia's large nuclear fuel cycle facilities.

Apart from EMERCOM of Russia's detachments and teams, the forces/ facilities from Rosatom's regional emergency technical centers and emergency-rescue teams can be operatively involved. The permanent constituent of the RERS/Rosatom activity for the past decade has become enhancement of the emergency response system during regular exercises and trainings.

The Chernobyl lesson was not lost but we need further advance today. The world is rapidly changing along with the safety guiding lines. The views on environmental or overall safety have cardinally changed for the twenty post-Chernobyl years. Considerable efforts are taken in the current nuclear power to prevent severe beyond-the-design-basis accidents and to exclude radiological effects for the public and the environment in any within-the-design-basis accidents. However, the items of nuclear and radiation safety are not limited by the provision of normal operation for the NPP. Great efforts are still required to prevent and increase the preparedness to eliminate the consequences of radiological emergencies.

Not only the nuclear industry should learn the Chernobyl lessons. A considerable number of human-induced emergencies has occurred in the post-accident period both in Russia and in the world. The experience in serious errors and practical actions on safety improvement in nuclear power should serve an illustrative example for all hazardous branches of industrial activity.

### ***Results of Investigation of Accident Consequences***

Almost the 20-year experience in the investigation of **radiological health effects of the accident** has shown that radiation has caused the following:

- 134 cases of acute radiation sickness among the firemen and the employees of the Chernobyl NPP being at the place of accident in the first 24 hours after the explosion. Out of this number, 28 people died during several months that followed the accident; another 19 persons died of different reasons during the subsequent 19 years;
- Up to half of 226 thyroid cancers revealed among the children and teenagers (at the moment of accident) from the Bryansk region in the period of 1991–2003. The survival after operations makes up 99%. As of today, only one child has died of all the children who underwent operations. The available causation between an abrupt increase in thyroid cancer among the children and emergency radioactive releases is of no doubt for Byelorussia and Ukraine as well.

In addition, according to the data of the Russian State Medical-and-Dosimetry Register (RSMDR), several tens of leucoses resulted during the past years in death of the Russian liquidators who had obtained the exposure doses above 100 mSv might be associated with radiation. Overall, approximately 5,000 individuals out of this group of liquidators (about



60,000 people) have died of all the reasons during twenty years. However, the total death-rate among the liquidators does not exceed the corresponding values for the male population of Russia. The similar situation with respect to the total mortality is observed in the cohort of Byelorussian and Ukrainian participants in the elimination of accident consequences.

As for the radiological nature of other kinds of health damage among the liquidators and the public from the Chernobyl areas of the three countries affected (solid carcinomas, cardiovascular diseases, immunity/fertility decrease, genetic defects, etc.), the conclusion of the multi-year research is negative. It is impossible to reveal the radiation contribution at the background of more significant negative factors, such as decrease in the living conditions, deterioration in the quality/ availability of medical assistance, etc. The analysis of medical and population health indices for the public and the liquidators affected in Byelorussia/Russia/Ukraine has not revealed any public death-rate deviations from the spontaneous levels that would indicate to negative effects of radiation, including the death rate of leucoses, solid carcinomas (except for thyroid cancer) and non-cancer diseases. The basic reason for the above mentioned is low absorbed doses and a high spontaneous level of cancer development and mortality, except for leucoses. In the opinion of the majority of experts, it is unlikely to reveal, except for thyroid cancer, the cases of other remote (stochastic) effects, such as increase in the cancer development frequency and genetic anomalies among the public. At the same time, it is necessary to continue medical observation of the public affected by the accident and update the appropriate demonstrative base associated with a limited nature of radiological effects of the accident.

As compared to the Chernobyl radiation, **other factors** of the accident such as chronic psychological stress, an infringement of the accustomed lifestyle, the restrictions on economic activity, as well as material losses associated with the accident have caused a greater damage to people.

Underestimate of **social factors** is one of the main lessons of Chernobyl. They play a key role in radiation contamination of any size. The decisions of authorities should be based on a comprehensive assessment of their long-term social and economic consequences, including the analysis of their impact on social psychology. Crisis development of the public political situation is possible even during rapid objective improvement of the radiation status. The effective and scientifically justified measures on the elimination of radiological consequences can be performed only under conditions of public trust in the authorities and when running the consistent information policy.

The current social obligations to the majority of people affected by the accident are the state's payment for its own mistakes. Social protection will remain the priority of the state Chernobyl programs for the nearest future. At the same time, the state-level elaboration of a scientifically justified strategy is required for social protection of different categories of the citizens mobilized by the state to execute the health risk-related work. Not only long-term individual interest but also public one should serve the strategy basis.

**Environmental effects of the accident** are of limited nature and do not become apparent outside the Exclusion zone. If the radiation damage consequences were observed in flora and fauna of the above zone in the initial post-accident period, they both recovered from radiation effects several years after. At the practically full lack of human-induced pressure, the Exclusion zone has become the unique reserve of biological variety (a

white-tailed eagle was not found in Polesje before 1986 and now it lives and reproduces in this particular zone).

The issues associated with the constraints in natural management, agriculture, forestry and water consumption on the lands affected by the accident are precisely defined and well predicted. The scientifically important monitoring can be focused in limited areas with typical landscape characteristics and geochemical peculiarities of soils.

### ***Efficiency of Protective Measures***

The protective measures carried out in agriculture of the Bryansk/Kaluga/Oryol/Tula regions were aimed in the initial post-accident period to decrease contamination of the products (first, of milk and meat) produced in the public or private sectors. The practice has shown that the measures were effective and proportional to radiation effects. The reduction in the mid 1990s of protective actions on the most contaminated lands increased radioactive contamination of agricultural production. No doubt that at present the performance of a package of protective measures in agriculture is essential, though, in the limited number of districts of the Bryansk region where it is impossible to produce the products that meet the valid hygienic requirements without taking the appropriate actions.

Such countermeasures as decontamination and improvement of the localities aimed to reduce external exposure were effective only in the first years following the accident. Afterwards, the radiation status did not require large-scale decontamination. The measures on improvement of the settlements remain effective from the standpoint of social and economic development and to a certain extent make for the exposure dose reduction.

The decisions on mass relocation adopted three years after the accident were not sufficiently justified from the standpoint of radiation protection for the public and did not take into account the scale of economic, social and psychological consequences. Such decisions turned out to be considerable economic losses and new social problems both to the residents of the region and the state.

Implementation of such measures as construction of social sites, roads and water supply facilities in the contaminated areas and gasification of the settlements had a long-term positive impact on the social and economic infrastructure of the region and improved public living conditions. Taking into account the increasing value of economic priorities in remediation of the areas and public rehabilitation, the above measures rank first in the state programs on elimination of the Chernobyl consequences.

The constraints in consumption of local and forest products played an important role in the reduction of dose load for the public in the first post-accident years. However, such measures infringed on the accustomed lifestyle and the economic way of life of rural population; besides, they were not properly supported by information measures. The constraints introduced on poorly contaminated lands were excessive in some cases and might be weakened or removed in the earlier period. Even nowadays, the recommendations on safe forest exploitation and residence remain actual for the inhabitants of the most contaminated areas. The efficiency of both introduction and review of the constraints depends in many respects on implementation of a package of measures that provide information support for the decisions approved.

Radioactive contamination of the forests reduced significantly the opportunity of timber purchasing and saw-timber production as well as complicated the planned forestry engineering activities. For the past years, a considerable part of forestry issues has been solved due to the development and implementation of new ways of forest utilization in the contaminated areas.

### *Vistas*

The analysis of basic consequences of the Chernobyl accident as well as the efficiency of decisions made to protect the public gives the basis for defining the principal trends to be used to advance in the items of mitigation of the accident consequences. Today, the most actual is the increase in addressability when rendering social assistance to the liquidators and the public affected by the accident as well as the implementation of those measures in the field of medical, economic, social or psychological rehabilitation that have proved to be most effective.

The medical assistance programs able to improve physical and mental health of the individuals who have happened to be in a difficult social and economic situation should continue to develop in the radio-contaminated areas. The radioepidemiological research should go on, as its results are vital to confirm the right orientation for practical health protection and information activity.

Correction of the Russian normative and legislative basis is one of the most actual objectives for both the authorities and the scientific community. The Chernobyl accident has demonstrated that the unjustified strict zoning criteria and branch standards are a serious impediment to the process of recovery of normal life activity in the contaminated areas.

Scientific justification for a number of legislatively fixed provisions on elimination of the catastrophe consequences, including the zoning criteria, the use of the accumulated dose notion, etc., requires a review aimed to elaborate adequate decisions and increase the addressability of the actions performed. At present, such paradoxical situations are possible when the area is considered to be radio-contaminated according to the Russian national criteria, while people in the developed European countries live without any constraints at the same level of radioactive contamination and do not feel any concern about it.

Though agricultural monitoring needs certain reduction, it will be long required. No doubt that some protective measures aimed to decrease the levels of contaminated agricultural products and proved to be good remain important not only from radiological but also social standpoint. The state should provide their sufficiency and addressability at a new stage, having focused the efforts in sites where the measures produce an apparent effect. That mostly concerns the economy of south-west districts of the Bryansk region.

The protective or other measures that should be provided by the state for the forestry located in the contaminated areas have approximately the same geography. Apart from it, it is necessary to more actively implement the new timber processing technologies which make it possible to obtain not only normatively pure but also competitive production.

Improvement of the normative and legislative basis will provide more effective spending of public funds for the goals of elimination of the Chernobyl consequences. The items of information provision for the state policy in the above area should rank higher in the coming years.

As for continuation of the research, proper correlation of its targets with the program on accident consequences is required. For this purpose, there is no need in new scientific discoveries and large-scale research, though, some work of extremely high scientific qualification is required to create and support the demonstrative basis as well as to analyze the lessons.

**The state still faces the challenge to create conditions for the most radio-contaminated areas to be transferred from the survival regime to that of development in the situation when this objective has not been fully solved in the country on the whole.**

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