C. SUBSTANTIVE RESEARCH IN RUSSIA: SYSTEMS APPROACH TO CASE STUDIES OF DISASTERS

7. RADIATION ACCIDENT AT SIBERIAN CHEMICAL COMPLEX IN 1993: REMINISCENT OF CHERNOBYL

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Introduction

Tomsk-7 (another name of this town is Seversk) is situated on the bank of the Tom River, 15 kilometers to the northwest of Tomsk, an administrative center of the West Siberian region with 500,000 citizens The population of Tomsk-7 is about 150,000, consisting mainly of those working at the Sibirski chemical complex (SCC) and the members of their families. The emergence of this town in the later 1940s was directly correlated with the creation of a special military-industrial enterprise, the just mentioned SCC that incorporated several plants designated primarily for producing highly enriched uranium and plutonium for nuclear warheads. Analogous enterprises were constructed nearly at the same time in the town of Chelyabinsk-40 (now called Snezhinsk), adjacent to Kyshtym in the Ural region and the town of Krasnoyarsk-26 or Atomgrad in East Siberia. Later industrial functions of those facilities, including the SCC, were augmented with the recycling of the processed reactor fuel for nuclear power plants (Illesh and Kostyukovski, 1993b).

The military profile of the main industrial complex of the town that existed for more than 40 years naturally predetermined the secret status of Tomsk-7. Up to the later 1980s, the public knew nothing about the existence and functions of this town, that did not even appear in USSR maps. At present, this status of the town has been somewhat modified but the bulk of the earlier restrictions primarily regarding the SCC still exist

The first nuclear reactor was put into action in 1951. and later it was supplemented with four other uranium and graphite channel reactors (or Chernobyl type) reactors. By now, following the new industrial conversion strategy, three of them that enriched uranium and plutonium for nuclear warheads have been closed down The other two have kept their recycling operations along with producing electricity and heat for Tomsk-7 and Tomsk, covering 100 percent and 40 percent respectively of their needs (Illesh and Kostyukovski, 1993a; Illesh and Kostyukovski, 1993b) The start of conversion has also brought to life initiatives to deploy or move the dismantled nuclear warhead depository in Tomsk-7, thus objectively increasing both nuclear and radiation risks. Besides recycled uranium and plutonium for foreign and federal nuclear power plants. and electricity and heat for adjacent communities, special chemicals with unique characteristics and consumer goods are also supplied by the SCC (Tsarev, 1933).

At one of those factories, the radiochemical plant, located 15 km. from Tomsk-7 and 28 km from Tomsk, on April 6, 1993 at 12 58 a.m , an explosion of the extractor filled with a radioactive solution resulted in the destruction of the apparatus and the containment building, and an emission of radionuclei into the environment that fell mainly on uninhabited territory. The radiation doses absorbed at the plant site and its protection zone in general registered well below standard safety levels.

This gave grounds for officials and responsible federal departments to assess the situation as:

> medically nonhazardous but still requiring control and certain technical and organizational countermeasures to reduce the potential irradiation of the population (Akt, 1993).

They also strongly stressed that according to the International Atomic Energy Agency (IAEA) scale, the situation should be treated as a serious incident (level or category III), but in no way comparable to Chernobyl. Thus, it might appear that this incident had nothing to do with any industrial crisis.

However, the following system analysis of the causes and consequences of the radiation accident at Tomsk-7, as well as of the preparedness, response and recovery activities argues that should a conclusion would be too narrow and hasty.

A System Analysis of the Causes

The Tomsk-7 accident resulted from a complex of both political and socioeconomic conditions that may be treated as a set of external factors, and interdependent human, organizational and technological errors and flaws within the SCC that can be viewed as internal factors. Earlier studies by other researchers suggest that such factors are practically organic to every industrial crisis (see Kates, Hohenemser and Kasperson, 1985; Kasperson and Kasperson, 1988; Mitroff, Pauchant and Shrivastava, 1988; Lagadec, 1990; Meshkati, 1991; Quarantelli, 1992; Clarke and Short, 1993). To show how the whole cluster of factors developed and resulted in an explosion and to make the system analysis dynamic, we add a time dimension. Thus it is reasonable to use another dual framework subdividing these factors into deep (antecedent) and direct (immediate) prerequisites and causes for the accident.

The links in the causal chain of events that led to the accident are undoubtedly related to the latter and lie within the organization, i.e., the SCC, which failed to provide adequate personnel training, technological auditing and operations control, etc. for preventing the explosion Meanwhile, the initial and perhaps key elements of that chain should be looked for outside the SCC and Tomsk-7. We believe that the roots of not only the accident, but also antecedent radiation emergencies--including the worst and most famous cases of Cheliabinsk-40 in 1957 and Chernobyl in 1986 as well--are deep and intrinsically rooted in the specific historical development of the Soviet and Russian nuclear complex systems (Porfiriev et al, 1993).

Deep or External Prerequisites: Military-Political Causes

The international situation in the mid 1940s, the race for leadership in getting an atomic bomb between Germany, the USA and the USSR, predetermined for decades ahead the basic direction of research and development (R & D) in the nuclear field. Since that time, in the peripheral, practically non-populated areas of the Soviet Union, a process was initiated of building ten "shadow" (i.e., not public) towns, led by Cheliabinsk-40 and Tomsk-7, within which were secret facilities for producing uranium for nuclear warheads. The same or nearly the same process of building plants took place in the USA and the United Kingdom (UK), thus insuring many common problems in the development of all nuclear complexes.

Among the most important was the nuclear and radiation safety of the personnel of the plants, the neighboring communities, and the environment. On the other hand, the nearly exclusive orientation toward the urgent development of new weapons set back attempts at solutions of critical R & D issues, e.g., how low radiation doses impacted human health was replaced by studying the effects of large doses, which are typical of nuclear warfare radiation. Also other practical issues, including human, technological and organizational aspects of nuclear and radiation safety were often neglected.

That could not but increase the risk in functioning nuclear facilities. It was quite natural that the first accidents in 1957 occurred just at those military nuclear plants in Windscale in the UK, and Cheliabinsk-40 in the USSR. Nearly at the same time the first though less serious accidents started to occur at the SCC nuclear facilities in Tomsk-7. In total, for more than a 40 year period from 1951 on, there occurred 23 accidents that were never publicly reported (Biychaninova and Nekrasov, 1993: Tchernikh, 1993a; Kostyukovski, 1993).

Secrecy and Weakness of Legal Regulation

A veil of secrecy covered not only the Soviet military nuclear programs and facilities, but those in other countries as well, in the UK in particular. For example, detailed information concerning the earlier mentioned radiation accident at Windscale was declassified by the British government only in 1988 or more than 30 years later (Lyuti, 1988).

But in the Soviet Union the problem was that until the late 1980s the increasing number of classified military nuclear facilities preserved a policy of total secrecy. This restricted the access of even local personnel to routine information concerning radiation impacts on human health, let alone local communities. Scientists and engineers working at those top secret complexes could get only limited data relevant to their specific professional rank or orientation, and never got information on closely related issues.

As a result, serious problems in dealing with early warning and safety system development and for the learning of lessons from previous shortcomings in the design and construction of nuclear industrial plants, were never addressed This contributed to the recurrence of incidents and accidents at those plants in Tomsk-7, which actually occurred about once every two years. In recent years, the secrecy about the shadow towns was somewhat lessened, most of all because of the enactment of the 1992 Federal Act on Classified Administrative and Territorial Formations. Yet it is still not easy for plant personnel and especially local communities to get any important information (see Kariakina, 1993).

The secrecy factor is especially responsible for the continuing weakness in any legal regulation of the nuclear complexes. In a closed organizational and information system there was no need and possibility for the development and enactment of laws that could guarantee persons or communities legal protection against nuclear and radiation hazards As to nuclear plant personnel, their status was tightly regulated by instructions regarding their obligations and limitations, but with little legal support for their rights.

Despite substantial sociopolitical changes in Russia and other former Soviet republics since the late 1980s, the situation about nuclear legal regulations still remains complicated. On one hand. the Federal Act for the Social Protection of Citizens Who Suffered from the Chernobyl Disaster was enforced in 1991. It provided important community rights, including right-to-know information on radiation accident consequences, and also some compensations and preferences (i.e., privileges), etc. to victims and their families. As late as 1995, two paramount and long expected laws - the Nuclear Energy Act and the Radiation Safety of the Population Act - were enforced, although in the USA and Europe those have been used for several decades. On other hand no less important laws like the Act for Nuclear Impact Losses and the Radioactive Wastes Storage and Handling Act, although their drafts had been developed as early as 1991 and having analogues elsewhere in the world, have not yet been adopted. Governmental and parliamentary crises have been negatively impacting and delaying the enactment of a number of the key acts, thus limiting both the right of communities for protection against risks connected with nuclear plants, and the obligatory responsibility of owners to provide this protection for plant personnel (see Kariakina, 1993).

Neglecting the Priority of Human Factors

Among the deep (antecedent) prerequisites and causes of the Tomsk-7 accident, one should especially emphasize the multiyear trend of declining attention by top rank party and state officials responsible for Soviet economic progress in general, and the military and industrial complex development in particular, toward so-called human factors in nuclear and radiation safety. This trend began in the late 1950s and affected both the nuclear scientists and engineers and the operating personnel of the nuclear facilities

Academician Valery Legasov, well known to the world thanks to his outstanding activities during Chernobyl crisis, made the following comment on the situation in Soviet nuclear science in the 1960-mid 1980s

> Research organizations once powerful in the country were losing having the most modern equipment, were confronted

> with aging personnel and restrictions on new methods and approaches . . . There has grown a generation of engineers well trained in their specific areas of activities, but not treating critically the reactors and safety systems (Legasov, 1988)

Since the late 1950s, as far as the operating personnel of the nuclear plants are concerned, an effective economic system for labor motivation based on paying substantial bonuses for good safety records was substituted step by step by a considerable increase in salaries and a conspicuous cutting of those bonuses. In the following decades this naturally led to negative qualitative changes among personnel, and helped augment the number of incidents and accidents at the nuclear plants.

The Role of Sociopolitical Changes on the Eve of the 1990s

Since the latter half of the 1980s the situation in Soviet nuclear science and industry has become even more complicated. Perestroika, which encompasses both the Chernobyl disaster and the further dissolution of the Soviet Union, has been accompanied by a drastic decrease in sociopolitical priority of and financial support for relevant R & D activities for functioning nuclear plants and constructing new facilities.

One of the more acute problems is the chronic indebtedness of the electricity consumer companies to the producers/owners of nuclear plants, thus restricting the capacity to maintain and adequately modernize equipment as well as to increase the salaries of personnel. The equipment becomes obsolete while the quality of the personnel, including reactor operators, declines, which negatively impacts on the safety status of the plants.

This process has even reached the point where the chief executives of the nuclear plants take unprecedented measures such as decreasing the capacity of the plants to self-supporting levels as occurred in October 1993 at the Kola nuclear power plant. In 1995 and 1996, the chief executives and personnel of a few nuclear power plants were at the edge of strikes, although the latter are forbidden by the law and the participants may be prosecuted. But one can easily explain this paradox taking into account, for example, that during 10 months of the year 1996, the personnel of the Smolenskaia NPP received no payments at all, while the debt in salaries for the personnel of this plant, including specialists providing nuclear safety, surpassed 16 billion rubles (about $3 million dollars). (Rabotnikov, 1996).

As a result, nuclear plants in Russia continue to suffer from numerous malfunctions, incidents and sometime accidents. For example, even after the Chernobyl disaster, in 1987-1991, former Soviet plants had about 30 fires and in 1993 alone, two serious incidents occurred at the earlier mentioned nuclear complex in Snezhinsk (Chelyabinsk-40) This resulted from the poor quality of the equipment and the shortcomings in the training and performance of operators and managers These very factors served as the direct or internal ones for causing the Tomsk-7 accident.

Direct Causes and Development of the Accident

By the end of 1993, or more than half a year after the explosion, there was no consensus shared by all experts and the public on what were the causes of the accident. Nevertheless, in May 1993, the special governmental commission including representatives from responsible governmental departments and services (such as the Ministry for Nuclear Energy--that is Minatom; the Nuclear Regulatory Committee--that is Gosatomnadzor; and the State Committee for Civil Defense, Emergencies and Elimination of the Consequences of Natural Disasters - that is GKCS later reorganized into MCS or the Ministry for Civil Defense, Emergencies and Elimination of the Consequences of Natural Disasters) presented an official report with an agreed upon version of the case (Akt, 1993; Biychaninova and Nekrasov, 1993).

The situation prior to the accident

Early on the morning of April 6, 1993, routine quarterly operations were initiated at the extractor of uranium and plutonium. This consisted of a 34.1 cubic meter vessel made from stainless steel and located underground at a depth of 10.4 meters. About four cubic meters of nitrogen acid solution of uranium derived from an extraction of uranium, plutonium, neptunium and thorium was put into the apparatus. At that time, it contained a total of 8,773 kg. of uranium, 310 g of plutonium, 248 g. of neptunium and 142 of thorium and some organic fractions from a solution that had not been adequately purified at previous technological processing stages.

A few hours later, at approximately at 11:00 a.m., one more portion of an analogous solution of nitrogen acid was added. Just directly before the accident, the vessel in total contained about 21 cubic meters of nitrogen acid solution of uranium with an activity of 537 Ci of alpha- and 22 Ci of beta-radiation respectively. This could be explained by the earlier removal of the most hazardous nuclei including plutonium (Arutiunian et al, 1993; Illesh and Kostyukovki, 1993a; Illesh, 1993b; Kunitsina, 1993; Tchernikh, 1993b).

The triggering event

An inadequate purification of the solution of organic matter and excessive concentration of nitrogen acid should be considered as the initial prerequisites or causes of the accident, which was later radially aggravated by actions of the workers or operators. Operator F, performed the last manipulation, making an improper mixing and managing it poorly, thus initiating the start of a catalytic dissolution process that facilitated the creation of an organic solution which further reacted with nitrogen acid. This reaction, characterized by a chain effect and the creation of large volumes of vapor and gases prone to explosion, was the chemical rather than nuclear origin of the accident that occurred. There were no existing conditions for a nuclear chain reaction at all.

Having detected the increased pressure in the vessel, the operator opened the valve to cut the pressure, but made it inaccurately by loosening the valve only partially, thus accelerating the sequence of events by not following the standard procedure for removing gases from the apparatus The workers involved also were too late in switching on the special pressure safety system (that however was not "fool proof"). In six minutes the pressure reached 17 atm which exceeded by 3.5 times the reliability standard. Considering that the reliability coefficient in this apparatus equaled only two against five in international standards for such a device, meant that in the situation there naturally was a surpassing of a critical level (Illesh and Kostyukovski, 1993b: Illesh, 1993b; Kostyukovski, 1993; Biychaninova and Nekrasov, 1993).

Human, organizational and technological factors and their culmination

The mixed material in the vessel and the gases that leaked into the protective casing were ignited by a spark and exploded. The upper cover of the extractor was torn away and the walls of the casing were ruined, thus very much resembling the situation in the Chernobyl disaster occasion. Through the large hole made by the explosion, the radioactive gases start to flow into the environment where there was a north west wind blowing at a speed of 9-12 meters per second. That is why the main outflow from the ruined vessel came into the ventilation system equipped with filters that were not designed for such emergency emissions. The explosion also resulted in an ignition of technological type garbage inside the building and in a small part of the 11-meter high roof that had been constructed with combustible materials.

Outside the building, from 3:00 p.m. and up to 1:00 a.m. of the next day, the temperature was 3.2 Centigrade A snowfall facilitated the accelerated fallout from the radionuclei cloud moving in a northeasterly direction, mainly on the surface inside the safety protective zone around the plant. The emergency situation forced a suspension of work operations at the plant. About three hours after the explosion or at approximately 4:00 p.m. the aerosol emission ceased (Akt, 1993; Biychaninova and Nekrasov, 1993; Semenchenko, 1993; Tchernikh, 1993a; Tchernikh, 1993b).

All official commissions participating in the investigation, in assessing the input of each of the human, technological and organizational factors to the development of the accident, especially stressed the role of operator errors and partly the insufficient automatic control system. However, a few experts scrutinizing the direct causes of the accident have given a higher priority for what happened to design shortcomings in the apparatus.

The latter point in particular is argued by a specialist who worked at the affected plant (Guriev, 1993). He cites extensively the results of US and British research on analogous explosions in those countries, as well as previous accidents over more than a 30 year period at the SCC. This research found that explosions resulted from an inappropriateness of the extraction technology per se, which under certain conditions might cause a shattering effect unpreventable by any kind of construction. That is why Guriev argues that the responsibility for the Tomsk-7 accident should be shared not only by the plant operators, but by the designing engineers and the auditing commission as well that gave a license for the plant to be constructed.

Other experts believe that the very origin of the raw materials used played a key role in creating the accident. Their version rests on the fact that the radioactive components processed in the plant's extractor came from France. French processed uranium, although more or less close to the Russian analog in some parameters, contains higher concentration of a few uranium isotopes that favor additional radiation and heat emission. This creates a difference in the technology for processing Russian and French uranium, and if there is a mix of those two brands of uranium inside the extractor, the lack of correspondence in the separation scheme could lead to an overheating that might lead to an explosion (Belianinov, 1993).

All versions, mentioned above, of the causes of the Tomsk-7 accident have still not been officially rejected and thus can be treated as equally possible. Summing them up, one may conclude that the flaws or shortcomings in the apparatus design, its technology control and safety systems, should be considered as the main prerequisites for the incident, with operator errors or failures serving as a trigger. Using combustible materials in the construction of the roof was an aggravating element, while the time of occurrence and favorable meteorological situation were positively mitigating factors in the accident.

Even now it is hard to be completely sure about the nature of the mentioned human shortcomings, but at least two circumstances can be stressed even today. First, poor training, upgrading and supervising of personnel, and poor technological and administrative discipline performance contributed in particular to a sharp decrease in the number of plant inspections and a weakness in internal safety organization and planning procedures

Second, the ignoring or neglecting psychological aspects for the safe management of complex technological systems, is analogous to the extractor in the SCC. A few years ago this point was especially stressed by the experts studying the causes of the Chernobyl disaster. In particular, they underlined the negative impact of an unfavorable geomagnetic situation on the personnel undertaking experiments at the Chernobyl nuclear power plant on the night of April 25, 1986. As to the Tomsk-7 accident, the same arguments for a high possibility of explosions at aging nuclear plants in April 1993 were pointed out as early as January and then March 1933 by I. Gavrilin, a research fellow of the Biological Institute of the Sibir chapter of the Russian Academy of Sciences (Vzriv, 1993). He first warned the federal government and later the regional authorities about the hazard, and recommended a suspension of the operation of nuclear reactors. Naturally to follow that advice in a full sense was unrealistic, but one should not hesitate in taking such warnings seriously and in a timely way strengthening supervision and control over both nuclear devices and personnel.

The Consequences of the Accident and Its Assessment

The main and direct result of the explosion was a radioactive contamination of territory. According to the estimates of Rosgidromet (The Federal Hydrometeorology and Environmental Monitoring Service of Russia), the total emission volume varied from 40 to

400 Ci for beta- and .2-.6 for alpha (Pt-239) isotopes activity. So the maximum emission values for both isotopes did not exceed 20 percent and 3.1percent respectively of the activity in the apparatus before the accident (Arutiunian et al, 1993). At the same time, they were 50-100 thousand times less than the emissions that followed the Kyshtym (Cheliabinsk-40) and the Chernobyl radiation disasters.

In general, the radioactive contamination of territory resulting from the Tomsk-7 accident resembled that of Chernobyl in being uneven and spotty, and thus creating a pronounced difference in radiation levels and densities. This pattern also makes it difficult to estimate accurately the area of the polluted territory. The spectrum of the contamination scale assessments, including those for the site of the plant where the fallout was most intensive, is rather wide. The head of the technology department of the plant believed the roof of the plant where the gamma radiation exposure dose rate equaled to two /R/h was the most irradiated place, while the GKCS experts argued that this indicator was 300 times greater, reaching 650 mR/h (Akt, 1993; Kunitsina, 1993).

According to some information sources, preliminary data showed that on the day following the Tomsk-7 accident, that is, on April 7, the radiation exposure dose level "at the explosion site" was 30 mR/h (Illesh and Kostyukovski, 1993a), or 200 times more than the natural radiation level or 50 times in excess of the sanitary protective standard. A week later, the GKCS experts stated that at the distance of 1.5 meters from the extractor, the radiation exposure dose level reached 5 R/h or nearly 170 times greater than the earlier mentioned figure, and "15-20 meters away from the plant's walls" it varied from .25 to 45 mR/h (Akt, 1993).

Alternative information sources stated those radiation exposure dose levels directly at the explosion's epicenter, even after intensive deactivation measures in May, measured 10-15 R/h (Kostyukovki, 1993) or twice as large as the GKCS and Minatom had reported. Noteworthy in any case is that the last two assessment values exceed natural radiation exposure levels by the order of three. In June 1993 supposedly due to effective deactivation countermeasure, the dose level substantially decreased to .1-.2 mR/h. At the site of the plant, within the 100 mcR/h isoline, the contaminated area equaled seven square kilometers (Akt, 1993; Kostyukovski, 1933).

No less contrasts in radiation levels and area assessments exist for the territory outside the plant. The discrepancy in the official data from responsible federal bodies in some cases is more than the figure of ten, e.g., assessments for the contaminated area varied from 10 to 200 square kilometers. This can be seen in Table # 1 which is based on mass media information containing references to the mentioned official data sources, in particular, Minatom.

According to these sources, outside the plant the highest radiation exposure dose level of 400 mcR/h was registered in the forest area (Illesh and Kostyukovski, 1993b). A few unofficial or independent experts and journalists consider the forest to be the most hazardous place where animals and birds could pick up and spread radioactive particles.

No pollution was detected in the air and the rivers. As to the land outside the forest area, about 1,130 hectares of agricultural lands including 743 hectares of arable lands, 248 hectares of hayfields and 139 hectares of pastures, were contaminated.

The specialists in Minatom also pointed out another small contaminated area about 300-800 meters long on part of the Tomsk-Samus road. At the same time, the GKCS experts supported by Rosgidromet and Rosgeokom (the State Geological Committee of the Russian Federation) argued that very part of the road was at least five times as large and was the most contaminated. The radiation exposure dose levels there on April 7, varying from 250 to 480 mcR/h, were the maximum registered outside of the plant (see Table # 1).

The official sources reported that the most distant polluted point was the village of Georgievka, 22 kilometers from the explosion site. The radiation exposure level there was 30-35 mcR/h which twice exceeds the natural radiation level but which still is not hazardous for human health (Illesh and Yakov, 1933; Tomsk-7, 1993). Nevertheless, the measurements performed by independent researchers from Tomsk showed that the radiation exposure dose interval in that village was 70-100 mcR/h, and at some spots reached 2 mR/h (Boltachev, 1993; Tchernikh, 1993b). Rosgidromet and the GKCS reconnaissance data obtained for the territory within a 60-kilometer radius from the explosion epicenter shows that the maximum length and area of the contamination track zone were 28 kilometers and 123 square kilometers respectively. The relevant figures for the territory with contamination levels over the natural radiation doses exceeded 30 kilometers and were about 200 square kilometers respectively (see Table # 1).

Those figures confirm in particular that the village of Chernaia Rechka, 34 kilometers from the explosion site, was within the contamination track zone. The already mentioned federal organizations also believed that the radiation exposure doses at some spots were up to 50 mcR/h, while in the village of Georgievka the gamma radiation levels varied from 21 to 42 mcR/h. Moreover, the specialists from Minpriroda (the Ministry of Environment and Natural Resources of the Russian Federation) found several spots of up to 160 square meters each where radiation exposure doses exceeded that figure from five to six times (Akt, 1993; Arutiunian et al, 1993; Illesh, 1993c).

Even the most conservative and careful approach to the cited statistics can reach the following conclusions. The radioactive contamination of territory considerably exceeded both the initial assessments made by responsible government bodies and the federal radiation safety standards for urban and sanitary protective zones, i.e., 20 and 60 mcR/h, respectively. The fallout outside the plant and the SCC area spread a distance of more than 30 kilometers and covered a substantial part of that territory. It should also be stated that the whole area potentially suffering from the accident exceeds conspicuously the earlier mentioned figure, considering that the woodlands alone impacted by the radioactive fallout consisted of 200 square kilometers (and the possibility of the radionuclei spreading because of forest fires, windstorms, etc. was real as the post-Chernobyl experience suggests).

Table 1

Contamination by radioactive fallout from the SCC accident

Date	Information source	Distance from epicenter of explosion (km)	Radiation exposure dose (mcR/h)	Contaminated area (sq. km)
04/07/93	Minatom (ITAR-TASS)	-	From a few mR/h to a few R/h	A few hundreds of sq. m
04/07/93	GKCS	19	40	10
04/08/93	GKCS	<15	400 - 250	-
04/08/93	GKCS	15 - 18	250 - 120	-
04/08/93	GKCS	18 - 22	120 - 35	-
04/08/93	GKCS	-	<400	200
04/08/93	Tomsk-7 CC*	-	300	-
04/08/93	Tomsk-7 COME*	22	70 - 102	-
04/08/93	Tomsk-7 COME*f	3	25 - 100	-
04/09/93	Minatom	10	30	<90
04/12/93	Minatom	-	-	35
04/12/93	Minatom	-	-	120
04/15/93	GKCS	-	>60	30 - 35
04/15/93	GKCS	-	>15	123
04/16/93	Rosgidromet, Geokom	-	-	100
04/16/93	Rosgidromet, Geokom	-	30	50
04/16/93	Rosgidromet, Goelkom	-	240 - 480	-
04/19/93	IGCE*	-	-	100
04/21/93	Anonymous	-	>20	250
04/93	RNC*	Plant's boundary	500	-
05/93	"Eraecos"*	-	-	800
05/93	Minatom	-	-	123

* Tomsk-7 CC - the City Council of Tomsk-7; Tosk-7 COME - the City Comiitte for Ecology of Tomsk-7; IGCE - Institute for global climate and ecology of Rosgidromet; RNC - Russian Nuclear Center "Kurchatovski Institute" of the Russian Academy of Sciences; "Eraecos" - Association "Eraecos"