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RADIATION ACCIDENT AT TOMSK-7:
A SYSTEM ANALYSIS CASE STUDY

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ABSTRACT

A system analysis of the most serious radiation accident after Chernobyl that occurred in the former secret town of Tomsk-7 in Siberia in Russia is presented. This is the first attempt in Russia, to the author's knowledge, to scrutinize the anatomy of an accident that fortunately did not develop into a great industrial crisis or even disaster. It is argued that the fundamental causes of the Tomsk-7 accident are deeply rooted in the history of the economic and political development of the former Soviet Union in general, and the development policy of the nuclear complex for decades covered by secrecy and military orientation in particular. Those served as an environment for specific human, organizational and technological factors that directly facilitated the explosion. A description of the ecological, medical and sociopsychological aftermaths of the Tomsk-7 accident as well as the related response and recovery activities is presented.
1. 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 which 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, 1993a).

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 which did not even appear in USSR maps. At present, this status of the town has been somewhat softened 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 graphite moderator (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% and 40% 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 factories (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 which 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 Authority (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 the 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 with the latter and lie within the organization, i.e., the SCC, that 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, 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 very time, in the peripheral, practically non-populated areas of the Soviet Union, a process was initiated of erecting 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 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 towards 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 publically 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. But 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 nearly the same. The only exception is in the 1991 Federal Act for the Social Protection of Citizens Who Suffered from the Chernobyl Disaster, which provides important community rights, including right-to-know information on radiation accident consequences, and also provides victims some compensations and preferences (i.e., privileges), etc. But even now in Russia, drafts of the Nuclear Energy Act—the Nuclear and Radiation Safety Act—developed as early as 1990 and having analogues elsewhere in the world for decades, have not yet been adopted. The parliamentary crises in the fall of 1993 further delayed the enactment of these 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, towards 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 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 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.

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 suffered about 30 fires and in 1993 alone, two serious incidents occurred at the earlier mentioned nuclear complex in Snezhinsk (Chelyabinsk-40), resulting from the poor quality of the equipment and 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 and Emergencies—that is GKCS) 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 which consisted of a 34.1 cubic meters 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 which at that time 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 the analogous solution of nitrogen acid was added. Just directly before the accident, the vessel contained in total 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, which could be explained by the earlier removal of the most hazardous nuclei including plutonium (Arutiunian, Gorshkov, Maximenko and Tkalia, 1993; Illesh and Kostyukovki, 1993a; Illesh, 1993b; Kunitsina, 1993; Tchernikh, 1993b).

The triggering event. 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 were later radially aggravated by actions of the workers or operators. Operator F, performed the last manipulation with an improper mixing and managed it poorly, thus initiating the start of a catalytic dissolution process which 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 which 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") and in six minutes the pressure reach 17 atm that 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, 1993; 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 which 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; Semenchenco, 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 was pointed out as early as January and then March, 1993 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% and 3.1% respectively of the activity in the apparatus before the accident (Arutiunian, Gorshkov, Maximenko and Tkalia, 1993). At the same time, they were 50-100 thousand times less than the emissions which 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 2 \( \text{R/h} \) was the most irradiated place, while the GKCS experts argued that this indicator was 300 times greater, reaching 650 \( \text{mR/h} \) (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 \( \text{mR/h} \) (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 \( \text{R/h} \) 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 \( \text{mR/h} \) (Akt, 1993).

Alternative information sources stated that radiation exposure dose levels directly at the explosion’s epicenter, even in May after intensive deactivation measures, measured 10-15 \( \text{R/h} \) (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 \( \text{mR/h} \). 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 Rosgeolkom (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).

According to the Rosgidromet and the GKCS reconnaissance data obtained for the territory, within a 60 kilometer radius from the explosion epicenter, the maximum length and area of the contamination track zone—with levels exceeding 15 mcR/h for gamma radiation—was 28 kilometers and 123 square kilometers respectively. The relevant figures for the territory with contamination levels over the natural radiation doses were greater, i.e., more than 30 kilometers and 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 the Minpriroda (Department of Nature 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, 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).

Assessments of the radioactive contamination structure or isotope composition of the fallout do not differ much as to scale. According to official data used by several "green" organizations, in mid April 1993 the isotope composition of the fallout in the area adjacent to the plant consisted mostly of heavy metals. These include isotopes with half lives from 35 days to one year, namely: Nb-95, Zr-95, Ru-103, Rh-106 (Illesh and Yakov, 1993). Such a composition at Tomsk-7 is obviously less hazardous when compared to Chernobyl given that at the end of the technological cycle the bulk of Cs-137 and nearly all Sr-90 with half lives of about 30 years had been removed at previous processing stages (Tchernikh, 1993c).

In the week after the explosion Minatom experts also stressed the negligible fallout of 8 mCi of Pt-239 (a considerably more dangerous isotope having a half life of about 20,000 years) per square kilometer, in particular in Georgievka. However, initially those experts failed to detect plutonium in the environment and sometimes even denied the possibility of such radionucleus being incorporated into emissions (see Sergei Shoigu, 1993).

Nevertheless, there are data that still have not been widely disseminated to the public and sometime even are absent in the official reports of the responsible governmental bodies. For example, the specialists from the Russian Research Center, "Kurchatovski Institute" found intensive radiation of Cs-137 isotopes at a distance of two kilometers from the explosion.
<table>
<thead>
<tr>
<th>Date</th>
<th>Information Source</th>
<th>Distance in KM From Epicenter of Explosion</th>
<th>Radiation Exposure Dose (mR/h)</th>
<th>Contained Area (sq. km.)</th>
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<tr>
<td>04/07/93</td>
<td>Minatom (ITAR-TASS-)</td>
<td>-</td>
<td>From a few mR/h to a few R/h</td>
<td>A few hundreds of sq. m</td>
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<td>04/07/93</td>
<td>GKCS</td>
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<td>400 - 250</td>
<td>-</td>
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<td>15 - 18</td>
<td>250 - 120</td>
<td>-</td>
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<td>18 - 22</td>
<td>120 - 35</td>
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<td>200</td>
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<td>04/93</td>
<td>RNC &quot;Curchatovski Institute&quot; plant's boundary</td>
<td>-</td>
<td>500</td>
<td>-</td>
</tr>
<tr>
<td>05/93</td>
<td>Association &quot;Eraecos&quot;</td>
<td>-</td>
<td>-</td>
<td>800</td>
</tr>
<tr>
<td>05/93</td>
<td>Minatom</td>
<td>-</td>
<td>-</td>
<td>123</td>
</tr>
</tbody>
</table>
epicenter which proved the presence of cesium in the fallout products (Borisov, Buturlin and Maleev, 1993). Those specialists as well as experts from Rosgeolkom have detected isotopes of Sb-125 having half lives of about three years, while a group from the Tomsk Politechnical University found two hot particles with sizes of 8-10 mcM and radiation exposure doses of 5 and 22 mR/h respectively. The great hazardousness of such particles is well known both to specialists and the public because of the experience of the Chernobyl disaster (Arutiunian, Gorshkov, Maximenko and Tkalia, 1993; Borisov, Buturlin and Maleev, 1993; Illesh, 1993a).

At the same time, bearing in mind that the fallout primarily fell on the sanitary protective zones near the plant site and on uninhabited woodland areas, it may be argued that the exposure of both personnel and local communities was rather limited. Our educated guess is that the maximum number of persons immediately affected by the accident did not exceed 200, mainly plant personnel and firefighters, dramatically less than the impact of Chernobyl on millions of persons.

That is why, the Tomsk-7 accident's impact on human health and safety, especially in terms of dead bodies, wounded and evacuated persons was not very much (although there is some luck in the situation in that it could have been much worse if personnel had not been absent, if it had not been lunch time and if there had been less favorable winds), although the ecological consequences were notable although far less than that of Chernobyl. Also, in contrast to the accident that had taken place more than 40 years before which resulted in two deaths, the explosion of the extractor at the SCC in April 1993 did not lead to immediate human losses or lethal irradiation of anyone.

At the time of the explosion there were about 160 persons inside the plant, including 30 workers from the emergency medical service and firefighting units taking countermeasures in the immediate vicinity of the epicenter immediately after the accident. The GKCS reported that the maximum individual radiation dose registered for two persons was seven mSv which is 14% of the annual permissible limited for personnel and other category "A" persons during the normal functioning of the plant, and less than 3% of that for the one only emergency irradiation. An additional individual got a 6 mSv dose. In total there were four persons close to the ruined apparatus who received more than 5 mSv dose which was considered as the annual permissible irradiation limit for the population (see Table 2, next page)

Official sources point out that as to individuals outside the plant only two communities, the village of Georgievka with 30 inhabitants and to a lesser extent the village of Chernaia Rechka, were within the radioactive explosion track. But the doses there were substantially lower than permissible limits and thus not hazardous to human health. The total beta-activity of the fall out did not
Table 2

<table>
<thead>
<tr>
<th>Dose mZv</th>
<th>Number of Persons Irradiated</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-.2</td>
<td>8</td>
<td>26.6</td>
</tr>
<tr>
<td>.2-.3</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>.3-.4</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>.4-.5</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>.5-1.0</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>1.0-2.0</td>
<td>5</td>
<td>16.7</td>
</tr>
<tr>
<td>2.0-3.0</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>3.0-4.0</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>4.0-6.0</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>6.0-7.0</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>7.0</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

exceed in those localities 50 Ci while the overall dose of internal and external irradiation was less than 5 mSv for forecasted life expectancy. These official figures are supported by assessments made by independent experts from the RNC "Kurchatovski Institute". They calculated that with an average radioactive density equal to 2 Ci per square kilometer the additional external radiation dose for the first postaccident year would not be more than .4 mSv, while in the next year it would be about .08 which is well below the 1 mSv considered as a starting threshold for federal nuclear hazard regulation (Borisov, Buturlin and Maleev, 1993; Romanov, 1993).

Although they noted the important fact that the radioactive cloud in general missed both Tomsk-7 and Tomsk and left those localities relatively safe, experts nevertheless pointed out local contamination spots within those areas. For instance, such a spot was detected at one of the bus stops where the radiation exposure dose levels varied from 50 to 90 mCr/h. Also certain dangers may stem from hot particles, two of those as already mentioned being found by Tomsk researchers. Such particles have great energy potential and may be easily transported long distances inflicting damage to human health through inhalation, the eating of meals and the drinking of water (Tarasov, 1993).

Though the Tomsk-7 accident did not create serious problems in terms of somatic and genetic health, the cited data and assessments do not provide 100% grounds for being sure that the consequences for human health are completely negligible. This is so if taken
into account are the latest results of research on low dose radiological effects and accumulation of additional accident doses, with those produced by natural K-40, U and Th radionuclies as well as radioactive contamination caused by multiyear effects from the SCC nuclear reactors and global radioactive fallout. That is why the conclusion that the:

radiological situation presents no hazard for living and working in the vicinity of the exploded plant but requires continuing control and monitoring

drawn in the final report of the federal task commission should be considered correct.

Besides, the 1979 Three Mile Island accident as well as the 1986 Chernobyl disaster also suggest that everyone should pay special attention to the sociopsychological repercussions of an accident and psychic or mental health effects on neighboring communities. Two days after the explosion, that is on April 8, those living in the village of Naumovka adjacent to Georgievka—especially women known to show fear at lower levels (see Drabek, 1986)—in the light of rumors about the issuance of special tablets for Tomsk-7 residents began to express alarm for their own health as well as that of their children. The women complained about tiredness, headaches and general indisposition. No less an alarm level was shown in the neighboring village of Malinovka where a few local residents confessed to being alarmed and buying all the iodine stock in the nearest village drug stores (Kondratiev, 1993), reflecting the grim days of Chernobyl. Analogous reports were also circulating in Tomsk-7 and discussed in particular by the chief of the sanitary and epidemiological service of the town (Kunitsina, 1993).

At the same time, there were no objective reasons for such responses given the earlier data presented concerning the fallout composition and radiation exposure doses in those villages. But as will be discussed later, lacking true and necessary information, the stress type behavior manifested, is quite logical.

4. Response To and Alleviation Of the Accident’s Aftermath

The explosion at the plant and the consequent dispersion of a radioactive cloud beyond the SCC boundaries served as a catalyst for the response by the local and regional authorities, nearby communities, and the special services designated for taking countermeasures and the localization and alleviation of emergencies. The timeliness and effectiveness in fulfilling such tasks in Tomsk-7 should be at least noted.
One of the most critical problems was that of alerting or warning relevant services and bodies at the local and regional levels as well as related federal departments, especially the GECKOS. The collected data testifies to substantial tardiness in the alerting of the services and chief managers of the plant, the CS and Minatom. Information about the explosion at 12:58 p.m. on April 6 was received by the civil defense chief of Tomsk-7 at 1:19; by the SCC chief engineer at 1:20; by the chapter of the town’s Department for Security at 1:55, or in other words, 17, 22 and 55 minutes later. The warning reached town, regional and federal authorities even later. For instance, the head of the Tomsk regional administration learned of the accident only at 2:30 p.m. while residents of Tomsk-7 and Tomsk heard about it by radio an hour and more than an hour later (Arutiunian, Gorshkov, Maximenko and Tkalia, 1933; Khronika, 1933; Pereubedit, 1993; Zakharov, 1993).

Soon after the accident the chief of the GKCS passed a special memorandum to the Russian parliament confessing that:

as it was in Chernobyl the information concerning the accident both at local and federal levels was communicated by Minatom with a considerable delay that could have resulted in tragic consequences (Illesh, 1993c)

And though the actual medical and radioecological effects of the accident, as discussed earlier, were not so serious, the delay varying from 17 minutes to nearly five hours meant that the radioactive cloud moved a distance of from nine to 60 kilometers, thus substantially increasing the contaminated area and abatement costs. Regular information for people through local and regional mass media was organized only after the evening of April 6.

In part, the reason for such a pronounced tardiness in warning is related to technological factors. The same memorandum stated that there was a:

lack of automatic radiation control system and local emergency warning system within a 30-km zone around the SCC (Illesh, 1993c).

The chief of the Tomsk-7 town council stressed the unsatisfactory functioning of existing communication lines and the lack of reserve ones (Illesh, 1993c; Pereubedit, 1993). The state of the technical capabilities for warning the population is even worse: for example, the residents of the village of Chernia Rechka could not be warned about the explosion at the SCC because the only telephone apparatus in the local school was not functioning (Malash, 1993).
Nevertheless, the main reasons for a lack of adequate alerting and warning systems in the southern part of the Tomsk region highly saturated with hazardous industries have to do with socioeconomic and organizational, including human factors. The underestimation of the importance and the problems in organizing comprehensive protection for both hazardous nuclear and chemical plant personnel and local communities is the prime reason for the weaknesses of local and regional warning systems, despite the recent grim experience of Chernobyl and recurrent accidents at the SCC per se. To our knowledge, there are still no press services at relevant groups in Tomsk-7 and Tomsk, including the civil defence, security, police, etc. that would provide official information to the mass media and directly to citizens. A key condition for this situation is the socioeconomic crisis impacting both the region and Russia as a whole, in the transition to the so-called "free market". Suffice it to note that the aforementioned telephone in Chernia Rechka did not function since it had been disconnected by the local service since the school simply had no money to pay for it (Malash, 1933; Zakharov, 1993).

The pronounced delay in warning local people and the federal government was also created by the passiveness and incompetence of local and regional authorities. This can be illustrated by the fact that on the day of the accident, April 6, and well after it had occurred (from 2:00 p.m. up to 7:00 p.m.), while the meeting of the Tomsk regional council was under way, none of the participants were informed and they learned about the explosion only when they went back home and looked at local and federal TV. The head of the council who was present at the meeting and who had received confidential information about the accident at 3:00 p.m., from the chief of the regional administration, had made no attempt to share it with his colleagues (Khronika, 1993).

Notable shortcomings in the warning system organization were further aggravated by flaws in the planning, preparedness for and operative response to the accident by the plant, local and regional authorities and responsible services, including the civil defense. In particular, the contingency preparedness planning did not provide for information sources operating directly from an accident site. The only source of information, for example, for the Tomsk-7 and regional civil defense services, was the SCC’s operative manager. A procedure for coordinating activities among the SCC, Tomsk-7 and regional authorities was not determined in advance (Pereubedit, 1993).

The technical and material support basis for the response and containment of the accident was weak, even given the current situation in Russia. As the chief of the special fire department of the Ministry of Interior of Russia said:
Among all so-called closed towns Tomsk-7 is the least equipped in terms of fire protection. For example, Cheliabinsk-65 (former Cheliabinsk-40) has developed an excellent fire protection and response system and it is considered criminal to economize on relevant costs (Semenchenko, 1993).

Confirming all these problems, the GKCS commission prescribed that the SCC director, the emergency commissions of Tomsk-7 and Tomsk should:

- revise contingency plans, insert corrections in time schedules and warning procedures in case of an emergency, improve the organization of radiation monitoring and control and the composition of means and forces designated for alleviation and recovery activities (Akt, 1993).

The earlier mentioned shortcomings led to delays and a decrease in the efficiency of the decisions made including tardiness in setting up in the aftermath of the accident the operative regional response headquarters. This was further followed by delay in organizing any reconnaissance, in mobilizing related means and forces, in warning and informing the population through the mass media and in starting a deactivation of the contaminated areas.

However, later, the responsible organizations succeeded in bringing the situation under control with the assistance of groups of high level experts who came from various regions to provide necessary operative help and consultations. But the key role belonged to the specialists from the affected facility, i.e., the SCC. Three stationary air monitoring posts subordinate to the environmental department of the SCC and located within the control area switched to a 24-hour schedule for taking samples for Ru-103, Rh-106, Zr-95 and Nb-95. The same department of the SCC also took samples of the waste waters of the complex, as well as from the waters of the Samuska and Tom rivers.

Radiation monitoring in potential fallout areas as well as the measurement of absorbed radiation doses was performed by the SCC's task force for external irradiation measuring, the Tomsk-7 sanitary and epidemiological station, medical post 81 of the Federal Department of Biomedical and Extreme Issues of the Ministry for Health of the Russian Federation, specialists from the Tomsk-7 Committee for Environment and Natural Resources, and emergency commissions of the SCC, Tomsk-7 and Tomsk. In addition, the latter commission had elements from the army, including aviation and signal service units for route reconnaissance and monitoring, as well as the Tomsk Politechnical University which participated in laboratory activities. Material support for all these actions were
provided by Helicopter Mi-8 with dosimeters, one radiological and 
three agrochemical laboratories together with three 
hydrometeorological posts (Arutiunian, Gorshkov, Maximenko and 
Tkalia, 1933; Tchernykh, 1993b).

Among the special forces involved in response activities, the fire 
and rescue service of Tomsk-7, as in Chernobyl, demonstrated high 
preparedness for and response effectiveness in counteracting the 
accident. The same can also be said of the militia (police) and 
medical services, although objectively to a lesser degree taking 
into account their relatively modest response effort stemming from 
the incomparably minor consequences of the Tomsk-7 explosion. 
Immediately after the explosion 53 firefighters and nine pieces of 
special firefighting equipment went to the plant site. A search 
for hotbeds of fires and radioactive contaminated spots was 
initiated and in less than ten minutes the fires inside the 
building and on the roof were put out. The fire and rescue 
personnel also actively participated in searching for injured 
persons but there was none. After their effort had finished, the 
firefighters had to leave their equipment for special antiradiation 
treatment which took several hours (Kishkurko, 1993; Sememchenko, 
1993).

The main task of the medical service was to provide monitoring of 
the radiation safety for those personnel directly involved in 
response and alleviating activities. Over April 6-8, a two day 
period, 65 persons were examined at the SCC medical post, including 
workers, firefighters, service personnel, and physicians who worked 
in the affected building and participated in the mentioned 
activities. No radioactive substances were detected in their 
bodies but since April 12 additional biophysical investigations 
have been undertaken. Medical groups also took an active part in 
preventive and selective screening actions in the communities 
reported to be within the radioactive fall out areas, but found 
that no one was affected (Arutiunian, Gorshkov, Maximenko and 
Tkalia, 1993).

As to the federal authorities, the response of several responsible 
governmental bodies and services to the accident was timely enough, 
being initiated almost immediately after getting a warning from the 
site. In organizational terms, the responsible departments 
include Minatom, the GKCS, the Ministry for Health, among others 
as well as various interdepartmental task forces which created 
commissions for assessing the causes and consequences of the 
accident and for making decisions on recovery and reconstruction 
activities.

On April 8, the Joint Commission, including representatives from 
Minatom, the Russian Academy of Sciences, the Department of 
Defense, the Ministry for Health, started its work under the chair 
of a person from the former department. This commission worked at
the SCC for ten days, up to April 17, and three days later on April 20, issued an official report to the Russian government. As early as the evening of April 6, a special team headed by the deputy chief of this committee was established and on the next day left Moscow for Tomsk-7. It stayed there until April 13 and together with experts from the other responsible organizations performed radiation reconnaissance at the accident site and assessed the aftermath. The Gosatomnadzor received a directive from the Russian government to perform an independent investigation on what had happened.

The Ministry for Foreign Affairs and Minatom sent a joint invitation to the IAEA to visit the site of the accident. The commission headed by the deputy direction of the nuclear safety department of the IAEA and including representatives from the United National Scientific Committee for Effects of Atomic Radiation and the secretary of the National Radiological Protection Council of Great Britain, visited Tomsk-7 on April 15-16 and examined the site and adjacent territory. It assessed the radioecological situation both at the plant site and the village of Georgievka and inspected the radiological protection laboratory of the SCC. The preliminary results of that work were the comments of the Commission chairman that stressed in particular the inadequacy of technical and material support and the outdated and old equipment, and that there would be a special official report by the IAEA on the accident.

In legal and organizational terms the response of the federal authorities to the Tomsk-7 accident involved the preparation of two important documents by the President and by the Supreme Soviet (parliament) of the Russian Federation, respectively. On April 9 the President of Russia, pointing out the aftermaths of the accident, issued special Regulation #224. This covered the taking of comprehensive measures on establishing governmental as well as nongovernmental control over the safety of civil and military nuclear facilities, as well as accelerating the development and putting into practice a concept for population protection and economic activities in territories that suffer from radioactive contamination. That Regulation provided directives to responsible departments, including Minatom, Minpriroda, etc. and to the Tomsk regional administration to promote necessary recovery measures for areas contaminated by the radioactive fallout, to assess losses and to calculate and pay compensation in the framework of established legal procedures. This document also served as a basis for the further enlarging the powers or commissions of the Gosatomnadzor, the main administrative instrument for nuclear facilities control as stated in Regulation #636 issued in October, 1993 (Rogozhin, 1993b).

In mid-April 1993, the Supreme Soviet represented by its Committee for Environmental and Natural Resources set up a special task force to analyze the causes and aftermath of the Tomsk-7 accident. A
month later it started hearings on a draft regulation, "About the alleviating and recovery measures in the aftermath of the accident which occurred on April 6, 1993 at the SCC in the Tomsk region."
The already noted shortcomings and flaws primarily at the local and regional levels in warning, preparedness for and response to the emergency situation, as well as the contradictions and discrepancy in information concerning the degree and scale of the radiation effects could not but affect the response of communities to the accident. The brief television address of the regional emergency commission made to the public on April 6 alarmed many of them, and the official data communicated to the newspapers either were delayed or simply were incomplete. This resulted in the emergence and spread of rumors as early as the next morning, thus disturbing seriously a considerable part of the population of the region (Kunitsina, 1933; Vigon, 1993).
The response of communities to the official messages by radio and TV was followed at least by great doubts and very often by complete distrust both as to the data and the interpretation provided by the SCC and local and regional authorities. Unfortunately, until now there has been no public opinion poll made that would present statistical data about the residents of Tomsk-7, Tomsk and the Tomsk region regarding whether the official information was perceived as incomplete or even false. Nevertheless, the analysis of the data in newspapers and polls in related situations, e.g., those connected with the nuclear testing at the Semipalatinsk proving grounds in 1940-1970s and its long term effects on the population of the Altai region bordering the Tomsk region in the southwest, makes probable that such a perception is dominant (Popov, Sazonov and Farberov, 1993; Zakharov, 1993).
This kind of perception is deeply rooted both in the multiyear secrecy covering the very existence of the SCC and the authorities keeping silent about its functioning and effects, and the distrust of people concerning the competence and honesty of federal, regional and local authorities which stemmed from their experience of previous accidents (the "Chernobyl syndrome"). It is also connected with the earlier mentioned discrepancy and tardiness of official information, as well as the delayed warning of citizens occasioned by the wish of the authorities to disregard the responsibility for inadequate preparedness and response to what had happened. Notably, a substantial portion of the population feel doubts or distrust not only towards official information from governmental sources, but also to mass media interpretations of the scale and degree of the accident, as well as having enough grounds to believe that newspapers and TV are inclined to overdramatize or distort real events.
Consequently, the residents of the Tomsk region like the majority of Russians prefer to reply upon the opinions and assessments of their friends, relatives, neighbors or simply acquaintances or even fortuitous others. Many people rely upon the mass media in the
absence of trustworthy data, on the one hand, and on the other, believe that there is a tendency for the media to sensationalize and therefore likely to misinterpret or misinform about what is going on. For example, on April 6, the Russian radio transmitted the news that the explosion at Tomsk-7 was creating a hazard for the lives of residents in nearby communities. Such a communication easily gave birth to rumors and fear (Kondratiev, 1993).

A group of Americans from an international financial corporation who happened to be assisting colleagues in Tomsk in a privatization effort, having heard the first radio messages, hastily left the city by taxicab. They were soon followed by other foreign businesspersons and specialists. The city authorities prohibited school children from walking or playing sports outdoors and a few schools suspended classes and let the pupils return to their homes. Some families in Tomsk took their children out of the city, and some left by airplane. Many persons remembering Chernobyl started to save vodka and iodine although there was no medical need for such behavior. In some kindergartens and schools in the first two days after the accident, iodine tablets were distributed by personnel with the best of intention to the children. But they got a reverse effect in some instances as a few children were poisoned by the iodine. Despite this and explanations by members of the regional emergency commission in the following several days, the demand for iodine tablets in the region surpassed all reasonable limits. A similar alarm and anxiety, especially in the first days, was also felt by residents of the communities located within the track of the radioactive fallout (Kishkurko, 1993; Kunitsina, 1993; Zakharov, 1993).

As to the recovery and liquidation of the aftermath of the accident, the key role in financing and practical implementation was assigned to the "culprit" of the accident, i.e., the SCC. Because of the measures undertaken as early as June 1993 the radiation exposure doses in the contaminated areas of the Tomsk region were cut by 25-30%. Terminating the deactivation of the affected areas and the burial of the affected apparatus have been cited as among the most urgent future countermeasures. After the nonreactive and unexploded part of the radioactive solution containing uranium and plutonium are taken off the apparatus, its residues should be examined and put into a concrete containment (Illesh, 1993b). These and other steps should facilitate a decrease of the radiation exposure dose levels in the affected territories by 2/3rds at the end of 1993, by 78% at the end of April 1994, and by 88% a year later.

The Tomsk region administration estimated that the losses from the accident were more than 200 billion rubles (using June 1993 prices) or about 200 million US dollars. But the chiefs of both the SCC and Minatom argue that this figure is at least an overestimation of the order of one. We agree. Indeed, in Chernobyl, the direct and indirect losses and costs for urgent recovery actions in total were
believed to be about ten billions of rubles in 1988 prices or approximately 10,000 billions of rubles in 1993 prices or about ten billion US dollars. The latter figure only exceeds by 50 times the mentioned estimation of the losses in the Tomsk-7 accident, keeping in mind that its medical, ecological and socioeconomic aftermaths are incomparably less than in Chernobyl.

Conclusion

Our system analysis of the Tomsk-7 radiation accident shows it to be the most serious incident at any nuclear facilities in the USSR after Chernobyl. It ranks first among the other emergencies that occurred after 1986 which resulted in the spreading of a radioactive cloud outside the industrial site of a plant and its sanitary protective zone. The accident inflicted substantial material and financial damage on the SCC, led to a radioactive contamination of a fraction of the territory in the Tomsk region, and aggravated the sociopsychological tension and alarmed tens of thousands of residents of the region, that stemming mainly from their distrust of information from official sources, primarily the authorities and administrations.

Though the medical, ecological and socioeconomic aftermaths of the Tomsk-7 accident were much more inferior to those in Chernobyl, some important characteristics of this accident makes it worthwhile to make a comparison. First of all, both cases have much in common in that deep or external as well as direct or internal causes are involved. The latter embrace a combination of errors in the design of the apparatus and the safety control systems; and human, primarily operator shortcomings stemming from improper training. Similar enough are also aggravating factors (e.g., using combustible materials in the construction of the roof) and helpful circumstances (e.g., meteorological conditions favoring the mostly densely populated areas such as towns and cities) in both accidents.

There are substantial grounds for comparing some of their consequences as well. These include similarities in fallout composition involving some analogous isotopes with long lives, although in different concentrations, and spotty contamination of nearby territories including forests as well as in the most impacted areas. Especially interesting in the aftermath of both accidents is the resemblance in preparedness for, response to and recovery by the plant, local and regional authorities, responsible governmental departments and communities. Both occasions are also characterized by numerous errors and drawbacks in planning and training at the prodrome phase, and by confusion, shortcomings, misunderstandings, and misinterpretation of the actual situation at the initial stages of response and recovery.
In particular, these conditions displayed themselves in a lack of capability for clear cut coordination of all means and forces that should be involved in effective planning and plan implementation; the lack or unavailability of necessary specialists and equipment within the region for routine operations (e.g., laboratory testing), and as a result, the need to draw upon external experts and services; delays in warning the population and authorities and distortions in the informing of the public about the causes and aftermath of the accident. As a result both the Chernobyl and the Tomsk-7 accidents have also much in common in terms of effects of a sociopsychological nature including nervousness, alarm and anxiety of people for their children and their own health and safety which stemmed from uncertainty and a distrust of official sources of information.

However, like in Chernobyl the fire, medical and militia services proved their high mobilization and preparedness potential as well as an effectiveness in the operative countermeasures they undertook, despite the backwardness of the material and technical bases in response to and recovery from the Tomsk-7 accident. All of this confirms that the experience of Chernobyl and the other radiation accidents and incidents, including those occurring at the SCC in the 1950-1990s, should be analyzed more thoroughly and comprehensively than they have been and that lessons from them should be practically implemented by all responsible organizations and authorities. In spite of the hard times being presently suffered by Russia there now exist necessary prerequisites and possibilities, in particular in the framework of the emerging Russian Warning and Emergency Management System (RUWEMAS).
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