Memorandum on decontamination work in the Chernobyl Exclusion Zone

August 28, 1991
Secret

On the Problems of Decontamination in the Exclusion Zone

The KGB Directorate of the Ukrainian SSR for Kiev and the Kiev Region, using its existing KGB capabilities, analysed the problems associated with decontamination work in the Exclusion Zone and identified possible solutions.

These measures resulted in the following findings.

According to experts, over 1,850,000,000,000,000,000 Bq [1,850,000 TBq] of radioactivity were released into the environment during the accident at Unit 4 of the Chernobyl Nuclear Power Plant. Radioactive fallout is characterized by extreme unevenness and a wide range of isotopes (caesium, strontium, plutonium, etc.). The average contamination density for cesium-137 ranges from 37,000,000,000 to 842,120,000,000,000 Bq/km^2 [0.037-842.12 TBq/km^2], and for strontium-90, from 111,000,000,000 to 66,600,000,000,000 Bq/km^2 [0.111-66.6 TBq/km^2].

A significant amount of radioactivity was concentrated not only on the earth's surface but also in water sources, buildings, and structures. The areas and bodies of water closest to the Chernobyl Nuclear Power Plant (Krasnyansko-Benevskaya floodplain, the Chernobyl Nuclear Power Plant cooling pond, the Pripyat backwater, and the Semikhodovsky ‘old man’) were subjected to the greatest contamination.

In accordance with the Chernobyl Nuclear Power Plant Restoration Concept of 1986, military personnel from the USSR Civil Defence Operational Group (CDOG) conducted large-scale decontamination work in the exclusion zone. This work was carried out in more than 700 settlements, involving 120,000 people over the course of four years. The total radiation dose was 150 million mSv. The total cost of the work was 1.5 billion roubles.

As a result of significant effort, material expenditure, and especially dose-related costs, a large volume of work was completed. Over 100 filter dams, bottom traps and weirs, a slurry wall, and a drainage curtain were constructed around the perimeter of the cooling pond. Soil was removed from an area of over 10 square kilometres. Hundreds of buildings and structures were dismantled, and a large number of industrial premises were cleaned.
However, the lack of specialised technologies meant that decontamination most often consisted of moving active material from one location to another, mechanically collecting contaminated soil, objects, and so on.

The lack of specialised equipment led to a significant increase in the volume of radioactive waste being processed. It should be noted that high-tech methods for decontaminating the earth's surface, buildings, and structures have not yet been developed.

At the same time, the measures taken significantly normalised the radiation situation in the plant's surroundings and production facilities, and made it possible to commission Units 1–3.

However, as subsequent developments showed, many of the technical solutions implemented at that time proved erroneous and could now become (and some already are) sources of negative phenomena.

This primarily concerns:
- a drainage curtain around the perimeter of the cooling pond, the activation of which, according to some experts, will lead to increased filtration of contaminated water from the pond into the Pripyat River floodplain;
- "diaphragm walls" around the plant's main structures, which led to a serious deterioration of the hydrological regime in the immediate area and a rise in groundwater levels;
- filter dams, which, in addition to becoming sources of secondary contamination as radioactivity accumulated without replacement of the filter material, seriously impaired the operation of the irrigation network and led to the flooding of significant areas within and beyond the zone;
– the disposal of a significant portion of buildings and structures, as well as contaminated land, on a "custom-made" basis, without the preparation of burial sites, has led to the creation of more than 800 temporary radioactive waste localisation sites (TRLS) that do not meet sanitary standards, concentrated not only in the zone but also beyond it, the location of many of which currently requires clarification and appropriate certification;
– the construction of clay lining at the base of the disposal sites and their subsequent lining with clays from the Chistogalovsky deposit, rather than bentonite clays (Cherkassy region), the disadvantage of which is their significant filtering capacity (only at the Burakovka waste disposal site are the screens made of bentonite clays).

Many of the currently noted deficiencies are explained by a lack of necessary experience and knowledge, erroneous conclusions, in particular regarding the long-term transition of radionuclides from the fuel matrix to a soluble state, as well as the extraordinary nature of the situation, which requires urgent action.

Recently, a number of new circumstances have been uncovered that have significantly complicated the situation in this area of work on the nuclear power plant.

Scientific research has revealed the following:
- the accelerated transition of radionuclides from the fuel matrix into a soluble state, including the dangerous radionuclide plutonium, a significant portion of which is concentrated in the "Red Forest" disposal site;
- the relatively high rate of movement of strontium-90 from the cooling pond into the Pripyat River floodplain;
- a significant rise in groundwater levels within the zone, especially in the vicinity of the plant.

Moreover, over the past five years, no fundamentally new methods for localising activity or decontamination work have been developed.

The current situation regarding decontamination is as follows.

The withdrawal from the zone in 1990 and the cessation of the activities of the USSR Civil Defence Group significantly reduced the scope of decontamination work.

Due to its small staff (720 people for two shifts) and poor technical equipment (not a single vehicle equipped for transporting radioactive waste (RW) meets sanitary requirements), the units of the Joint Venture Complex (SP Kompleks) and NPO Pripyat are primarily engaged in the demolition and disposal of dilapidated buildings and structures within a 10-kilometer zone of the station.

Currently, one of the pressing issues in the exclusion zone is monitoring the situation and reliably containing radioactive waste in 800 RWLROs.
As a result of an instrumental survey, the locations of these RWLROs were established; however, according to experts, their number is not final.

Groundwater conditions in the area of most of these sites are not monitored, making it impossible to draw conclusions about the dynamics of radionuclide dispersal.
This issue has been partially resolved in the area of radioactive waste disposal facilities (RWDFs - Burakovka, Podlesny, the third stage of the Chernobyl Nuclear Power Plant, Chistogalovka, and Tolsty Les), as well as the cooling pond, "Red Forest," where 70 monitoring wells have been installed. Several of these were previously in a technically faulty condition. Sampling is carried out once a month, and in some locations once every three months. However, the problem of quickly processing the obtained samples (on average, processing takes more than 24 hours) remains unresolved. Measures have been taken to ensure technical security at several RWDFs (Burakovka and Podlesny).

Recent studies have demonstrated the need to rebury the Podlesny waste disposal site, where operations have been suspended due to groundwater flooding. A total of over 10,000 cubic meters of waste must be reburied, including waste contaminated with caesium (with a total activity of 1,850,000,000,000,000 Bq [1,850,000 TBq]), strontium (1,850,000,000,000,000 Bq [1,850,000 TBq]), and plutonium (18,500,000,000,000 Bq [18,500 TBq]).

To a certain extent, the issue of normalising the situation, primarily with respect to the PVLRO, was linked to the launch of the Vector program, which envisioned the collection and disposal of radioactive waste in a permanent repository that meets sanitary requirements. A feasibility study for this project was developed by VNIPIET (Leningrad) in 1990–91. However, expert assessments yielded a rather contradictory picture, which could limit the effectiveness of the Vector program, as the proposed methods for reburying low-level waste are rejected by experts, and the development of new containment methods has not yet begun.

Furthermore, the removal of radioactive substances by groundwater is becoming increasingly important. Measures to block this migration path from such large areas are currently beyond technical capabilities.

According to estimates by specialists at the Dose Control Department (DCD) of the Pripyat Scientific Production Association, 4,070,000,000,000,000 Bq [4,070 TBq] of caesium radioisotopes, 4,699,000,000,000,000 Bq [4,669 TBq] of strontium, and 29,600,000,000,000 Bq [29,6 TBq] of plutonium are concentrated in the soil within the exclusion zone. Along with

this radioactive substance, the PVLRO and PZRO contain 4,810,000,000,000,000 Bq [4,810 TBq], 4,440,000,000,000,000 Bq [4,440 TBq], and 48,100,000,000 Bq [48.1 GBq] of these radioisotopes, respectively. The total area contaminated above permissible levels is 1,856 km^2.

Currently, the issues of radioactivity removal by water (due to runoff), wind, and man-made transport have been studied quite well, and practical measures have been developed and are being implemented. In particular, construction of a protective dam has begun on the left bank of the Pripyat River between the Tsyanka and the railway bridge.

It should be noted that an assessment of the retention capacity of soils in the vadose zone yielded data indicating not only the high sorption capacity of soils (3,700 Bq/dm^3 for strontium, 11,100 Bq/dm^3 for caesium), but also the presence of rapid migration pathways, which may indicate the active role of soils in polluting the subsurface hydrosphere. This is further facilitated by the fact that, by all characteristics, the largest and most contaminated part of the zone can be classified as a zone of active water exchange (surface-soil).

Current assessments of the groundwater conditions in the first aquifer (Quaternary sediments) show that the groundwater in the 10-kilometer zone (the dirtiest) contains caesium and strontium in ecologically significant quantities, in places exceeding permissible concentrations (DKB according to NRB-76).

Radionuclide concentrations in the water of the PZRO monitoring wells are no different from those in groundwater in particularly contaminated areas.
Of particular concern is the state of groundwater in the "red forest" area, where strontium levels reaching up to 3,330 Bq/L and plutonium in both true and colloidal forms were detected at a depth of 1–1.8 meters. After nuclear filters, the plutonium content in the filtrate is approximately 0.37-3.7 Bq/L.

An important conclusion is that with the implementation of proven methods for limiting surface runoff, wind, and man-made transport, the role of nuclide migration via groundwater will increase.

According to experts, the concept of temporary storage of low-level radioactive waste with subsequent reburial in a regional repository proposed under the Vector program is unjustified, as removing low-level waste (1.5 million m^3) from the zone is impractical, given that 80–85% of the radioactive waste remains on the ground within a 10-kilometer zone. In the event of solid radioactive waste reburial at the Vector site, it is necessary to separate low- and intermediate-level waste, followed by cementation and bituminisation.

One possible option is to consider the possibility of waste consolidation without transferring it directly to the PVLRO; however, this technology has not been adequately developed in our country (some experience exists in the United States).

It is noted that the proposed purely mechanical approach (excavation, compaction, and relocation) will have undesirable consequences due to the dispersal of radioactive waste during the opening of the PVLRO, the sorting of materials, and their transportation to the

Vector site. At the same time, the physical impossibility of completely extracting the radioactive waste and PVLRO, as well as the negative impact of the destruction of the surface layer, are noted.
Implementation of this program makes it impossible to localise radionuclides that have already become soluble. Estimating the half-life of strontium from hot micron-sized particles (5–10 years) suggests that up to 30% of strontium activity is already uncontrolled as mobile forms in the environment.

Taking this into account, it can be assumed that the volumes of reliably reburied strontium radionuclides are steadily declining. In this regard, it can be concluded that any delay in the implementation of the Vector program, especially for low-level waste, increasingly leads to the loss of any purpose for its implementation.

Therefore, experts conclude that it is necessary to focus primary efforts on:
– preserving some of the existing waste disposal sites;
– conducting further decontamination work at the most contaminated sites, with the development of more advanced equipment and technology;
– preparing medium- and high-level waste for disposal in accordance with international requirements;
– the development of technologies and systems for localising mobile forms of ecologically significant radionuclides, based on the concept of minimising the zone's hazard in the future.

Particular attention must be paid to the scientific support of ongoing work to avoid unnecessary losses and to stop activities that harm the environment and contribute to the spread of radioactive waste. Reburial of low-level waste may lead to material and radiation costs without tangible benefits.

At the same time, it is necessary to expedite the development of a concept for future human behaviour within the zone (either a complete cessation of any technological activity or the active implementation of planned programs).

Analysing the overall situation, most experts favour the need for a rapid development of a concept for the further decontamination of the zone, simultaneously with the development of equipment and technology.

We believe these issues should be raised for comprehensive consideration by the USSR Ministry of Atomic Energy and the Ukrainian SSR Ministry for the Protection of the Population from the Consequences of the Chernobyl Disaster.
The Regional Council of People's Deputies and the KGB of the Ukrainian SSR have been informed.

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