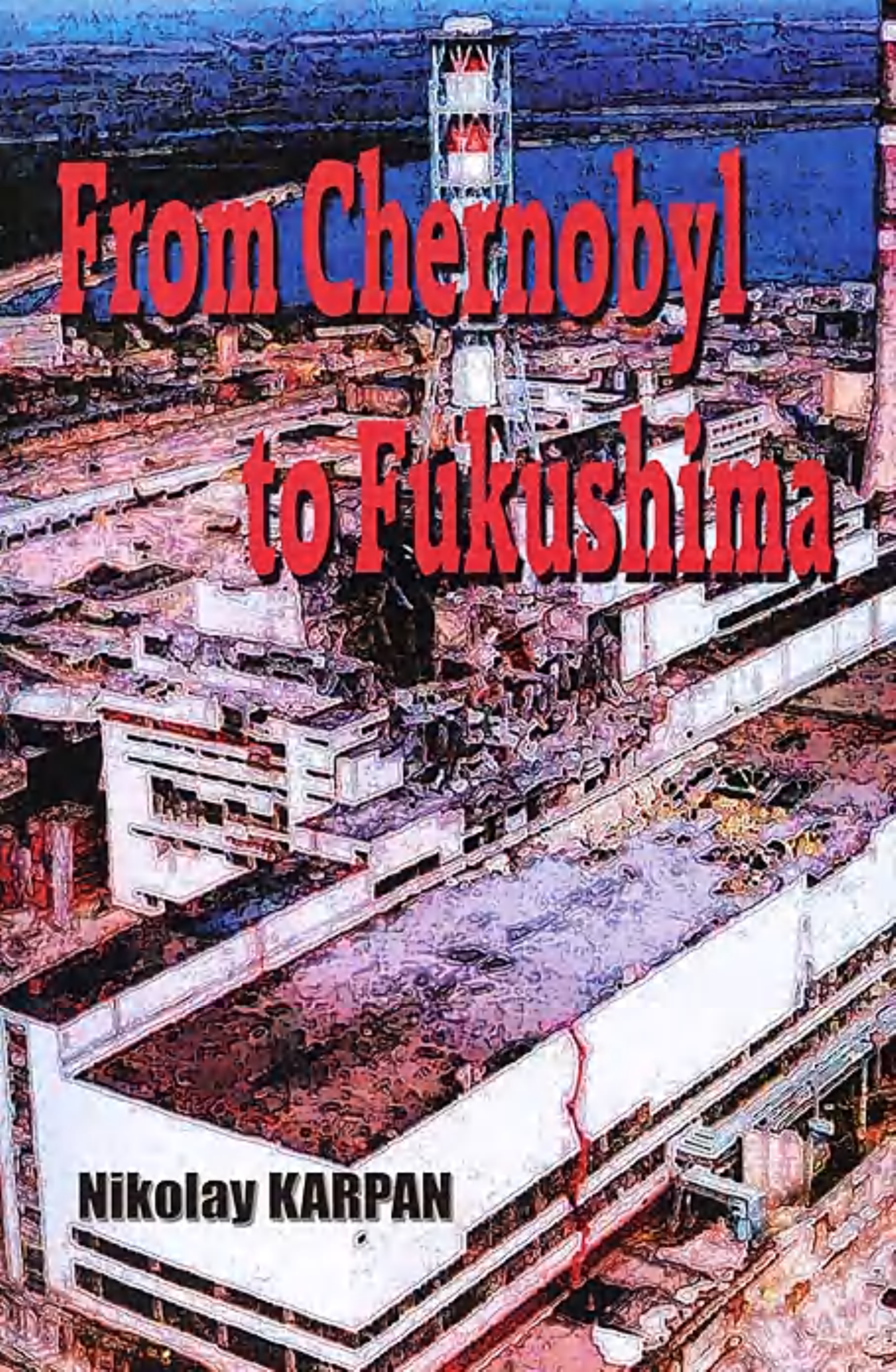

From Chernobyl to Fukushima

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In his new book - From Chernobyl to Fukushima - physicist and engineer Nikolay Karpan provides many earlier unknown facts on two major large-scale NPP accidents. With his long-term practical experience of work at many different NPPs, including ten years of work at the Chernobyl NPP (1979 - 1989), Nikolay Karpan fully experienced all aspects of life of "liquidators of nuclear accidents". The author provides an impressive account of initial hours of these disasters and gives interesting analysis of these historical events. The description of contemporary state of international Chernobyl projects and his account how the Chernobyl tragedy was transformed into a farce will leave nobody indifferent.

The events at Japanese Fukushima NPP are assessed from a professional point of view. For the first time the reader will see logical patterns in explosions of the Japanese reactors, associated with inadequate understanding of relations between the Man and the Nature with its mighty forces releasing in natural disasters.

Safe nuclear reactors do not exist and they cannot exist, as in addition to high operational temperature and pressure they contain deadly radioactive loads that release to the environment far too often - every 15 years (four off-design accidents in 57 years of the global nuclear power industry's history).

The book is a major event as it is written by a professional physicist about extreme developments he experienced himself, the book written honestly, stingingly and without pathos.

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Foreword

I never imagined that events of global significance may happen in my life, and that I would have to do a lot of hard work to remain a human being in this mess. The Chernobyl disaster swept like a massive roller across continents, countries, and on the fate of millions of people. Only Ukraine has lost half a million of its citizens (the book provides a documental proof of the fact), nothing to say about adverse health and economic impacts on its neighbours. Today, we can definitely say that even such superpower as the Soviet Union was not ready to accidents of the Chernobyl scale. Japan was not an exception either, suffering now from consequences of accidents at Fukushima NPP, which have not been fully revealed yet and can have very serious implications. So, the main thing I wanted to say to the reader of the book - it is unacceptable to have a blind faith in the power of the state and its apparatus. People should believe in themselves only and the should be able to pull themselves by hair out of any trouble. It is impossible to be indifferent to things that happen in my country of residence, which is called my Homeland. You can not allow incompetent officials and rulers of our lives to break us morally, as the Soviet Politburo did to Chernobyl staff.

List of Acronyms and Abbreviations

A&UB - administrative and utility building
APC - armoured personnel carrier
Bq - becquerel, Bq is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. Ci = 3.7×10^{10} Bq
CC - Criminal Code.
CCF - Chernobyl Commissioning Facility - a facility responsible for checking completed construction works and issuing work permit
CCR - Central Control Room (of NPP)
CE - Chief Engineer of the NPP.
Ci - curie, a unit of radioactivity, 1 Ci = 3.7×10^{10} Bq
CivDef - Civil Defence
CMT - Crisis Management Team
CoS - Chief of Staff - Senior officer of Civil Defence Unit
CPSU - Communist Party of the Soviet Union
CRCE - chief reactor control engineer
CS - Chemical Section of NPP
CSM - Chief Shift Manager
CSS - control and safety system.
CTCE - chief turbine control engineer.
CUCE - chief unit control engineer (unit of NPP is a reactor, connected turbines and other machinery which works jointly with this reactor)
DREG - program for diagnostic and registration of the Unit parameters.
EDR - exposure dose rate
EBRD - European Bank for Reconstruction and Development.
ERCS - Emergency Reactor Cooling System (also known as ECCS - Emergency Core Cooling System)
ERML - External Radiation Monitoring Laboratory.
ES - Electric Section of NPP
The first criticality - the first launch of a new reactor to check all associated systems
GAEN - Soviet Nuclear Power Supervision Authority (the USSR State Committee for Nuclear Power Industry Supervision), earlier named GAN.
Gy - gray (absorbed dose of radiation energy, 1 J/kg)
IAE - Kurchatov Institute of Atomic Energy (Moscow) of the USSR Academy of Science
INES - International Nuclear Event Scale, developed by IAEA in 1988. Since 1990, the scale was applied for uniform assessment of emergencies associated with radiation releases at NPPs. Later, the

scale was applied to all nuclear installations, associated with civil nuclear industry.

KhTP - Kharkov Turbine Plant.

MAC -maximal acceptable concentration

MCA - maximal credible accident.

MCP – main circulation pumps

MFCC - multipass forced circulation circuit.

MMMI - USSR Ministry of Medium Machine-building Industry (Ministry which was responsible for the Soviet A- bomb project and later for civil NPP program. Reorganised into the Ministry of Atomic Energy and Industry of the USSR in 1989)

MoI - Ministry of Interior.

MOX fuel - Mixed-Oxide fuel, containing oxides of several fissionable elements. The term is predominantly applied for mixtures of plutonium and uranium oxides (natural, enriched or depleted uranium). MOX fuel behaves similarly to the low enriched uranium oxide used as the conventional fuel of the majority of nuclear reactors (but not exactly in the same way).

NIKIET - R&D Institute of Power Engineering of the USSR Medium Machine-building Industry.

OCR - operator-controlled neutron absorbing rods.

Politbureau - ruling board of the CPSU Central Committee, the actual supreme decision-making body of the USSR.

R - roentgen, a unit of measure for exposure to ionizing radiation. 1 R is the amount of radiation required to generate one coulomb of ion pairs in one cubic centimetre of dry air at standard temperature and pressure (approx. 2.0819×10^9 ion pairs)

RBMK - Soviet-type graphite moderated reactor (all reactors of Chernobyl NPP were of this type)

RCR - reserve (back-up) Control Room of a NPP unit

rem - *r*-oentgen *e*-quivalent *m*-an: the amount of any ionizing radiation that has the same biological effectiveness as 1 rad of x-rays (see Sv below)

RS - Reactor Section of NPP

SDS - reactor shutdown system.

Sv - sievert, unit of dose equivalent radiation. In contrast to gray, sievert measures the equivalent dose of radiation, i.e. dose that have the same damaging effect as an equal dose of gamma rays.

TC - Training Centre (a full-scale unit control training simulator for reactor control engineers)

TF - training facility (a less sophisticated training facility for reactor control engineers)

TG - turbine generator.

TICS - Thermal Instrumentation and Control Section.

TP Dept. - Technical Planning and Performance Monitoring Department.
TS - Turbine (NPP) Section.
Unit CR - unit control room
VNIIAES - USSR R&D Institute of Nuclear Power Plants of the Ministry of Nuclear Power Industry.
WWER - Water-water power industry reactor (water is used as a coolant and neutron moderator).
YCL - Lenin Young Communist League of the USSR, also known as "Komsomol".

PART I. CHERNOBYL

Chapter 1. The Disaster's Beginning

Explosion that killed the city

Since April 21, 1986, I was in Moscow on a business mission. I had a return ticket to Pripyat with departure date of Friday, April 25. But on Thursday morning I got a severe headache that did not respond to analgesics for the whole day. I felt a strong desire to return home.

Having rounded up all my business I went to the railway terminal that evening, managed to alter the departure date and boarded a train to arrive home one day earlier. I was surprised to have my headache disappear when the train just started moving. Assuming that it was a good sign, I fel asleep and arrived in Pripyat in the morning of April 25.

It was a Friday, the last working day of the week. The weather was great, it was warm as in summer, sunny and windless. From the railway terminal I went home and immediately called the workplace phone number of my superior - Aleksandr Gobov, the Chief of the Nuclear Safety Department. He informed me that three reactor units operated in the standard mode, while Unit 4 would be shut down by the end of the day for scheduled maintenance repairs. When he heard that my visit to Moscow was successfully completed, he recommended me to take a day off and have a rest. Having been absent for a week, I was glad to spend a day with my family, my son was three at that time, and my daughter was one year old. The day passed in a moment, that evening we all went to bed late, having no idea that the next day will disturb the established way of life for a long time…

How I heard about the explosion

At 4 a.m. the phone started ringing and did not stop. I got up and answered. Alla Lesovaya, our relative from Chernobyl was calling. She was a teacher, an absolutely self-contained and tactful person, but now, feeling pity for her inconvenient call she worryingly asked what had happened with the plant? According to her words, two men (her neighbours in the residential block) arrived earlier than usual (they worked in the night shift) and alarmed the whole block. They worked at the construction site of units 5 and 6 of the NPP and witnessed the explosion at unit 4. I started to assure her that an explosion there was simply impossible. I told her that I called the plant on Friday and knew that unit 4 would be shut down by that night. The shut-down procedures are usually preceded by safety systems checks, including opening main safety valves - the operation that is accompanied by major releases of hot steam with a heavy noise that might resemble explosions. Alla calmed a little but I myself felt some unease and decided to clarify the situation.

Windows of our flat looked westward, opposite to the NPP, so I could not see anything at the plant from the flat. I decided to call the control room of Unit 4. The response was strange and unusual - all phones there were dead. I called Unit 3 - Konstantin Rodya, the chief reactor control engineer, answered the call and hurriedly said that “the explosion smashed away Unit 4 roof, state of the reactor itself is unknown but radiation level is very high. The scale of destruction is being assessed but to avoid trouble at neighbouring Unit 3, it is being urgently shut down”. I did not bother Rodya with questions that he could hardly answer and ran from the residential block. I looked to the plant - the building’s contour was different, at the place of Unit 4 roof I saw an irregularly shaped contour …

My first thought was - I must immediately run to my workplace! Only there I would be able to ascertain what had happened, to estimate the real threat to the NPP, the city and my family! For some obscure reason, my priorities at that time followed that very sequence - it was a strong effect of my Soviet background…

I hurriedly cycled trying to reach the plant by the shortest possible route, I left behind last houses of the city and entered the forest between the city and the NPP. “Stop! Where to?” I suddenly heard a Militia (police) officer who literally sprang on me from the dark. I saw another one on the left - they formed a human chain and blocked all routes from the city to the NPP site. They were not impressed by my arguments and persuasion - I tried in vain to explain them that as the acting deputy Chief of the Nuclear Safety Department I am absolutely needed there... They resolutely sent me back. They argued that all necessary persons were already present at the site.

Well... I decided to try another way to reach the NPP. I returned home and called the private phone number of my chief - Gobov. I found that he slept and heard nothing about the accident, he - the Chief of the Nuclear Safety Department - also was not called to his workplace by the accident alert system! What a strange accident it was - a whole reactor unit disappeared but specialists in reactor physics and nuclear safety stay at home uninformed, as if the accident notification was put aside!

I ran to Gobov’s and from his flat we managed to connect with the NPP Director Bryukhanov, we explained him that we cannot reach the plant by our own means and asked to dispatch a service transport. He proposed that we should come with Igor Aleksandrov, the Chief of the Chernobyl Commissioning Facility (CCF) - the director's car was already sent to collect him. We went to the road, where Anatoliy Kryat - the Chief of the Nuclear Physics Laboratory - waited for us (we warned him on the matter). In such a way, all four of us finally reached the NPP site at about 8 a.m. and immediately went to the underground bomb-proof shelter, where the Civil Defence (CivDef) Command Centre was located. The shelter was filled by top managers - the NPP Director, the Chief Engineer, the NPP Communist Party Secretary, their deputies and chiefs of some units.

I immediately discovered a strange thing there - we had no definite information. Nobody briefed us on the events, about the scale of damage of the reactor unit, on state of the reactor and its associated safety systems, on works being conducted and planned. We had no NPP site map with radioactive contamination levels. Yes, there was some explosion, but we had no idea on measures already taken that night and on the people involved, notwithstanding that members of the duty shift attempted to localise the accident from the moment of the explosion. In the CivDef bunker nobody told us anything on events in the reactor unit building, in the turbine room, about numbers of people who worked there, the ones evacuated to the medical unit and even rough estimates of radiation levels there…

All people who were present in the shelter formed two groups. Some top managers were clearly frustrated, including the NPP Director and the Chief Engineer. At the same time, some others tried to influence the situation, to alter it actively, trying to make things better. They formed a minority. Well, what had happened that night?

Gradually, I managed to ascertain a few things - at about 01:30, an explosion shattered reactor Unit 4. The explosion was witnessed by several dozens of people who either worked at the site nearby the unit or occasionally happened to be nearby. They included guards, construction workers and people who fished in the NPP cooling pond and in the Pripyat River. The circle of eyewitnesses who directly observed explosions and the initial stage of the disaster from the outside was smaller - there were about ten of them. Their stories are very important. Later I communicated with some of them - the ones I managed to find and record their stories. They were located far away from the unit and were not affected by the explosion itself, but they surely got some radiation doses.

Just a short story of eyewitnesses: two Chernobyl NPP workers fished at the cooling pond. They were well aware of the site layout. When they heard the first explosion they turned to the reactor units. Then they immediately heard the second, particularly loud sound, resembling the sound effect of a jet breaking the sound barrier. The ground trembled. They felt the impact wave. Black curling smoke moved upwards from Unit 4 building into the dark night sky, with sparks and hot pieces of different shapes. Then, as the black smoke dispersed they saw intensive glow, lighting the whole height (150 m) of the ventilation exhaust stack (the one installed at the building's roof between reactor units # 3 and # 4. They did not identify the glow as a fire – for them, it resembled a cold glow of ionized air.

I would like to quote another eyewitness, O.A. Romantsev: "I saw a flame over reactor Unit 4, in terms of its shape it looked like a candle flame or a torch. It was very dark, of iridescent darkish purple colour. The flame reached the top of the ventilation stack and seemed to descend, but then the second pop was heard - it resembled a geyser bubble bursting. 15 to 20 seconds later, another flame cone emerged - it was narrower comparatively to the first one, but that time it was 5 - 6 times higher. The flame cone also grew slowly, and then disappeared as before. The sound was like a cannon shot, sharp and booming".

I want to note that the latter eyewitness also does not speak of a fire, he admits only explosions and short flame flashes.

Aleksandr Petrovich Tumanov - an engineer of the Chernobyl Commissioning Facility (CCF) was nearby the explosion point. In his memo note he wrote: "From 23:30 to the event I stayed in room # 29 at 7th floor of the Administrative and Utility building # 2 (A&UB-2). At 01:25 - 27, I heard a roar and felt intensive vibration of the building. I automatically looked into the window and saw an upward flood of sparks. My first impression was that pieces of molten metal or some large and small burning rags flew out in all directions. I watched a large "piece" that landed on the upper part of roof of the building where the ventilation stack of units # 3 and # 4 was installed. The second "piece" landed on the roof of Unit 3 reactor building (at the place of the emergency CSS[1] tank of Unit 3). The third one landed on the Auxiliary Reactor Equipment (ARE) building roof. Having landed, two "pieces" continued to burn steadily, without blazing up, and only under the ventilation stack flames started to intensify. They burned for 20 to 30 minutes, I cannot specify the time more precisely.

At the initial moment I heard a roar, followed by a cracking sound and two loud thumps (or explosions, I cannot say definitely). The events that followed are described above".

So, after the explosion of Unit 4 reactor, only a few burning "pieces" landed at roofs of buildings nearby and the pieces burned for about 30 minutes.

The explosion completely destroyed the roof and the western wall of the central reactor building (CRB). The wall of the turbine room

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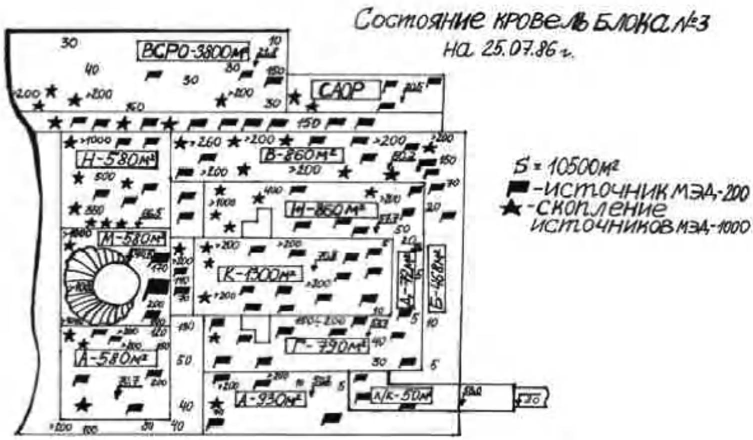
[1] *Reactor control and safety system*

collapsed, pieces of concrete constructions penetrated the roof of the turbine room and caused minor short-lived fires at the roof of Unit 3 building (due to falling nuclear fuel fragments). These small fires cannot be extinguished by water as water could just intensify their burning due to chemical reactions. Anyway, one could hardly expect to supply water to the roofs due to 2 reasons: first, available water pumps could not generate high enough pressure to raise water to 70 m height and, second, fire hydrant pipes leading to the roof of Unit 4 building were fractured by construction debris.

Note: Metal uranium powder (or filaments) is known to be prone to self-ignition in contact with air. Even uranium dioxide may be pyrophoric (UO_2 is used to produce nuclear fuel pills for fuel assemblies of RBMK-type nuclear reactors). According to V.S. Chirkin's reference manual "Thermophysical Properties of Nuclear Engineering Materials" - uranium dioxide powder (with particle size under 0.1 µm) may burn oxidising to triuranium octoxide. Accounting for these facts, small nuclear fuel fragments that were heated by the explosion to several thousand degrees, surely could self-ignite when contacting the air with formation of uranium triuranium octoxide U_3O_8. Presence of water may potentially only aggravate the situation as uranium reacts with hot water and steam, generating explosive hydrogen. If temperature decreases as uranium cools in the air (in absence of water and steam), uranium burning ceases.

The outline map below shows locations of nuclear fuel fragments that were released by the explosion from Unit 4 reactor and landed at the roof of Unit 3 building, the roof of Auxiliary Reactor Equipment (ARE) facility and the area under the ventilation stack. Radiation sources are marked by flags (contaminated construction debris with exposure dose rate (EDR) over 200 R/hour (2 Sv/hour) and stars (nuclear fuel fragments with gamma-radiation exposure rate over 1000 R/hour (10 Sv/hour). Figures in rectangles show roof area in square metres. The data refer to June 25, 1986 - measurements were made by specialists of the team of Yuriy Samoilenko that removed radioactive substances from the roofs. The outline map shows about 40 sources of radiation with exposure rate over 1000 R/hour (10 Sv/hour). The figures mean that any person who stayed there for even a half-hour would inevitably die. I have to note that on April 26, radiation levels on these roofs were even higher.

Note: even in 1990, in the northern section of the roof of Unit 3, fragments of fuel assemblies were found, as well as scattered uranium dioxide pills and other unprotected sources of ionising radiation with surface gamma-radiation exposure rate of up to 200 R/hour (2 Sv/hour) - these sources fell on the roof in 1986.



On these roofs, adjacent to the destroyed Unit 4 reactor building, the fire-fighters got lethal radiation doses. (See explanations in the text)

Actions of the fire fighters

Participants of these events described them as follows:

Dyatlov A.S., the chief manager of the tests (conducted before the explosion), the deputy CE-2 (the deputy Chief Engineer of 2nd stage of the Chernobyl NPP): "The roof and two walls of CRB simply disappeared. Through openings of the collapsed wall we saw flows of water, flashes of short circuits at electric installations, several fire sources... A few more fire sources (at that time minor ones) were observed at the roof of Unit 3 building... Several fire engines stayed nearby the building of Unit 3 backup control panel. I asked the driver of one of them who was in charge there and he pointed to a walking man. He was Lieutenant Vladimir Pravik, I knew him personally. I said Pravik that it is necessary to come to the collector of empty fire hydrant pipe leading to the roof. A fire-plug was also located nearby (Chernobyl. How it Happened. p. 62).

Major Telyatnikov L.P., the Chief Officer of the Ministry of Interior (MoI) Fire-fighting Unit of the Chernobyl NPP (FFU-2): "We surveyed Unit 4 building. Through holes left by concrete panels smashed out we could see cable rooms, where no fires were observed. However, from the central reactor room we clearly saw something like a blaze or glow... What was it? There is nothing except the reactor's "top face" in the central room, nothing was expected to burn there. We decided that it was the reactor itself that generated the glow. I called FFU-2 (the fire fighting unit serving the Chernobyl NPP only) and reported the situation for further transmission to Kiev... " (Andrey Svetlov. Fire-fighters against the Atom. How it Happened).

The fire-fighters arranged two work areas. Area # 1 covered the roof of the turbine room, fire-fighters Ivan Shavrey and Vladimir Prischepa from FFU-2 operated there. The second work area covered the roof of Unit 3 reactor building. Initially two lieutenants worked there - watch commander of FFU-2 Vladimir Pravik, and Viktor Kibenok - the watch commander of specialised MoI FFU-6 (the fire-fighting unit of Pripyat) and 6 other men.

Fire fighters' work area # 1 - the roof of the turbine room (to the fore).

Roofs of buildings where fire-fighters assigned to work area # 2 worked may be seen nearby the base of the ventilation exhaust stack (to the right from the stack one can see the roof of the reactor room of Unit 3).

According to V.A. Prischepa, a fire-fighter of the 3rd MoI FFU-2 watch unit, the situation at work area # 1 developed as follows: "We came to "A" line, connected the fire engine to a fire plug and lined the hose to the empty fire hydrant pipes leading to the roof of the turbine room. I climbed to the roof by the fire-escape. When I reached the roof, I saw that roof plates were damaged and some of them dropped down. I saw a small fire on the roof closer to western flank of Unit 4 building. It was

A segment of fire fighters' work area # 2 - the roof nearby Unit 4. Fragments of the reactor core are visible - the ones thrown by the explosion onto the roof of unit B where the ventilation stack is installed. The photo was taken from the North; the destroyed reactor room of Unit 4 may be seen in the right part of the left photo, on the left, the roof of the reactor room of Unit 3 is visible. The right photo provides a close-up view of one of the roofs.

a minor fire. I initially attempted to come closer to extinguish it, but roof plates were insecure. So, I returned and came there closer to the wall, along the fire hydrant pipe. I blanketed the fire by sand, as it was impossible to put a water hose there. Then I returned and saw Major Leonid Petrovich Telyatnikov at the fire escape. I reported the situation to him and he ordered: 'Arrange a fire watch there and stay there on the roof of the turbine room'. We did as ordered, and were on watch there with Shavrey I.M. till the morning (till 5 a.m. - N.K.).

Vladimir Alekseevich Prischepa wrote these lines in his memo when he was in Moscow Clinical Hospital # 6 in mid-May 1986, two weeks after the explosion of Unit 4. His words clearly suggest that no fires were observed at the roof of the turbine room. At the same time, in the same hospital and due to the same health implications (acute radiation sickness), Aleksandr Nechaev - the chief mechanic Engineer of the Reactor Section (RS) of the Chernobyl NPP - also underwent medical treatment there. He met Vladimir Prischepa there and remembered his words that the fire-fighters will never forgive their chief Major Telyatnikov who ordered them to stay on the roof without any real necessity, as no fires were observed there.

Developments in work area # 2 were reported by Lieutenant Pravik (see below extracts from the operational communication log-book of the Central Communications of the MoI Fire fighting Department of Kievskaya oblast Executive Committee, the log-book is stored now in the National Chernobyl Museum):

2:01 - an explosion happened in the reactor section of Unit 4 of the NPP. Reported by watch commander Pravik.

2:05 - the explosion fractured empty fire hydrant pipes, a fire hose is being laid. Reported by watch commander Pravik.

2:08 - setting two "A" nozzles onto the roof of Unit 3 building to cool it. Reported by watch commander Pravik.

Reports of Viktor Pravik do not refer to fires or ignition sources. His plans are limited to roofs' cooling only. These operations were associated with extreme risks, as multiple fragments of nuclear fuel with gamma-radiation exposure rates over 1000 roentgen/hour were scattered at the roof of still operational Unit 3. In addition, they breathed air filled with fuel dust and multiple toxic substances.

3:47 - We reached the point of request and started to ascertain the situation. There are no visible external fires, we continue surveying. Some persons are wounded, no casualties identified. Reported by Melnik (at 3:22 a.m., the operational unit of the MoI Firefighting Department of Kievskaya oblast Executive Committee arrived on the accident site, the unit was headed by MoI Major V.P. Melnik - N.K.)

From 3:30 to 4:00, operational personnel members of fire fighters' teams at work areas ## 1 and 2 were partly replaced. Ambulances more and more often evacuated people who were severely poisoned or displayed effects of radiation exposure (nausea, vomiting, loss of consciousness).

4:00 15 operational fire fighters' teams were concentrated at the accident site.

4:15 - the operational team of the Fire fighting Directorate of UkrSSR MoI arrived at the accident site, under command of MoI Colonel V.M. Gurin. He took command over further actions.

4:20 Accounting for high radiation levels, a decision was made to avoid locating newly arrived personnel and equipment closely to the accident site. They were concentrated at the distance of 5 km from the "site". Formation of reserve forces started.

A natural question arises: provided that there were no fires to stop, why did the chief fire fighters "burn" their subordinates by deadly radiation? Why did they keep so much as 15 operational teams nearby the damaged reactor unit, whose members got dangerous radiation exposure doses even without participating in practical operations? Some well informed people told me that in May 1986, the investigation proceedings were launched on these matters, but by August 1986 the investigation was cancelled, as the Party and the Soviet Government decided to give to Major Telyatnikov a title of Hero of the Soviet Union (he was one of the fire fighters under the investigation). Then, the criminal case on death of the fire fighters was destroyed, while all associated documents of the case were edited (including memo notes of the fire fighters involved, and operational registers) - i.e. falsified. The same happened to documents of the Civil Defence Staff (CivDef). I will provide proof of such “data cleaning” in the following chapters.

Chernobyl NPP. First hours after the explosion

The situation inside buildings and facilities of the Chernobyl NPP was an absolute nightmare. Multiple small fires emerged inside the turbine room after collapse of some roof plates. Huge installations of turbine generators there contained tons of inflammable lubricants and explosive hydrogen. The situation was further aggravated by fountains of boiling water and steam from fractured pipes, showering personnel, electric installations and control equipment units. All these internal fires in the turbine room caused by multiple short circuits in power cables damaged by falling roof plates and joists were particularly dangerous. I have to note that applicable fire safety manuals of nuclear power plants stipulated that internal fires should be extinguished by the NPP duty watch personnel instead of external fire fighters.

In order to avoid affecting the adjacent reactor Unit 3 by the damaged Unit 4, Unit 3 was shut down within an hour after the explosion.

Unit 4 reactor room operators (Oleg Genrikh and Anatoliy Kurguz) first of all managed to close the door to the reactor room, or, to be more precise - to the destroyed area without a roof. While doing that they got massive radiation doses - Oleg Genrikh survived but Anatoliy Kurgus died in a Moscow hospital two weeks later. Shift managers of NPP sections found all their workers, except Valeriy Khodemchuk who was dead, and led them out of dangerous places. Mortally wounded Vladimir Shashenok was taken away from the destruction zone. Workers of 5th shift team of Unit 4, led by Aleksandr Akimov started to make all the necessary things to ensure supply of water to the reactor. Jointly with Razim Davletbaev they also organized works in the turbine room. It was necessary to remove explosive hydrogen from generators and replace it by nitrogen, to cut off burning electric installations, to pump several tens of tons of turbine oil to storage tanks in order to prevent fire spreading through the turbine room to the still intact installations of reactor units ## 3, 2 and 1. Taking into account that all these works were conducted for almost 3 hours under high radiation exposure of up to 100 R/hour (1 Sv/hour), in the air filled by smoke and extremely toxic and radioactive dust, near sparking fractured electric cables, it was a hell of a work, nothing less. But nobody faltered, nobody deserted the place before the work was completed…

The personnel of Unit 4 played a crucial role - they extinguished fires in the turbine room and prevented explosions of the equipment installed there. The death toll of the emergency works was distributed unevenly. Six people died later among the fire fighters who surveyed the roof and kept watch post there for 4 hours to prevent fires. At the same time, there were 23 casualties among members of the NPP personnel who worked inside (plus one man from Kharkov who was on mission in Chernobyl to participate in the tests).

Why did we suffer such heavy losses? The NPP personnel worked in the demolition zone itself, in the most dangerous places. Initially they searched for MCP operator Valeriy Khodemchuk but could not find him as he was killed and buried under collapsed equipment and construction debris. They put mortally burned Vladimir Shashenok out from the flowmeters room. Trying to pump water to the destroyed reactor, as ordered by their superiors, they manually, in turns, opened huge valves of the feedwater unit, under a flow of contaminated water with dose rates up to 200 R/h (2 Sv/hour), and then they were not able to wash radioactive substances out and change into clean overalls for several hours. As a result, their skin was burned by “nuclear tan” and those who survived got life-long “reminders” - large persistent ulcerous wounds.

Naturally, casualty rates alone cannot measure heroism and risks. I do not attempt to diminish the role of fire fighters or representatives of other agencies who participated in disaster mitigation works from starting hours of the accident. Nonetheless, actions of Unit 4 personnel in the initial minutes and hours of the disaster represent the highest heroism, intelligent and suicidal. They realised that radiation “eats down” their strength, health and life, but they continued to work sensibly and efficiently, cutting off potentially fire- and explosion-prone installations, fractured power cables, repairing short circuits and ignition sources, launching backup equipment to avoid development of the accident into an uncontrolled disaster. These people overcame their natural self-preservation instincts, dizziness, exhausting nausea and weakness, they did their duty fearlessly and consciously. They did not think that they behave bravely and they had no idea how their efforts could be assessed later on. But even if they knew that, just a few days later, the top Soviet leaders would declare them criminals who caused the accident (shifting thus their own blame onto them), they surely would not refuse to fulfil their professional duty.

I am absolutely sure of the highest professionalism of 5th shift operators. Aleksandr Akimov, the chief shift manager of Unit 4, immediately realised what had happened: he confidently told Vladimir Babichev, who arrived to replace him on a call before the end of the night shift, that a "general radiation accident" happened (the highest accident level, associated with radioactive releases outside the NPP site). He correctly assessed the scale of the accident, clearly realised the whole danger of the event and reported the situation to the NPP top managers. He did not quit the accident zone and had done everything possible to ensure localisation of the accident and cooling the reactor unit. And he remained a Man in the mess. Just one example - in standard operational conditions, three senior engineer-operators and the shift manager operate the unit control centre. Akimov removed the youngest of them - Igor Kirshenbaum, the turbine control engineer (turbine room) who did not know the reactor unit layout. He ordered Kirshenbaum to leave: "You are not needed there and cannot help us, clear out".

Nobody panicked

Nobody of the duty shift personnel panicked or was taken aback by the explosion. Shift managers of NPP sections and units immediately started to operate according to emergency procedures. Everyone knew what to do, their emergency operation skills were polished in the course of accident mitigation drills. However, the actual scale of the accident and its effects were much higher than the maximal rated accident - the one accounted for in designing the reactor unit safety systems (protective, control, localising, radiation control systems, etc.) and stipulated in the emergency manuals (the Accident Mitigation Manual and the Personnel and Population Protection Plan).

The accident was the maximum credible one, but it posed a real and deadly threat to the NPP personnel and the outside population. Due to major efforts, by 6:35 the following things were ascertained:

- the scale of damages was (roughly) estimated;
- personnel members were removed from dangerous zones;
- fractured power cables were cut off, the emergency power supply circuit was restored, the necessary equipment was switched on;
- turbine oil was pumped to external tanks;
- explosive hydrogen was replaced in the generators;

- the hydrogen-generating electrolyser was cut off;
- the accident has been localized, fires inside the unit building were extinguished;
- staff of the occupational safety team in the turbine room measured radiation levels and installed warning signs;
- adjacent reactor of Unit 3 was shut down.

If you think it was a simple task, it was not. Personnel members paid by their LIVES for every step, for every action. In particular, many people owe their lives to Anatoliy Kurguz, the operator of the central room of the Reactor Section.

A.Kh. Kurguz

When he heard the explosion, he looked to the central reactor room and saw a thick curtain of hot steam and dust. A former submariner, he immediately decided to close the heavy pressurised door to the central room. His decision saved other operators from burns and radiation exposure; then he led them out from upper floors and then lost consciousness.

After the destruction of the reactor, numerous fires emerged in the turbine room posing a threat of explosion of hydrogen that is used to cool generators. It was necessary to discharge hydrogen from turbine generators ## 7 and 8, and replace it by nitrogen.

A. I. Baranov

K.G. Perchuk

V.S. Brazhnik

Anatoliy Baranov, a turbine mechanic, had done it.

Konstantin Perchuk, the chief mechanic of the turbine room (first he cut off pumps from fractured pipes, preventing inflow of radioactive water from deaerators into the turbine room) and Vyacheslav Brazhnik, a turbine mechanic both got lethal radiation exposure doses when they eliminated the turbine oil spill caused by oil pipe fractured by a falling roof plate. They also extinguished fires in the turbine room.

Aleksandr Lelechenko, the deputy chief manager of the Electric Section initially extinguished fires in the turbine room - he identified failed equipment units and cut them off the grid.

A.G. Lelechenko

V.I. Perevozchenko

A. A. Sitnikov

In the course of his equipment checks he found a fractured pipe at the electrolyser. He managed to reach the hydrogen supply main through debris and closed it. In the process, he got a lethal radiation dose and died ten days later

Viktor Lopatyuk, on-duty electrician, who assisted Aleksandr Lelechenko, also died.

Valeriy Perevozchenko, the shift manager of the Reaction Section (RS), led emergency works in the section. He searched for his wounded subordinates and led them out of the explosion zone. He saw the remains of Unit 4 reactor by his own eyes. He looked for Valeriy Khodemchuk, the operator of the main circulation pumps who was buried under the construction debris. His strength had its limits... He had got a lethal dose of radiation and died two weeks after the explosion.

Anatoliy Sitnikov, the deputy Chief Operational Engineer of the first stage of the Chernobyl NPP (units ## 1 and 2), was called to his workplace that night to assess the scale of damage and design accident mitigation measures. Accompanied by Vladimir Chugunov, the chief manager of RS-1, he surveyed the damaged reactor unit twice, assessing the scale of damage and participating in accident mitigation works. After his second area survey (in the morning) he returned to his office, but was unable to leave it himself. His wife, Elvira Sitnikova, was worried by his long absence, and finally she managed to contact him by phone and call medical assistance. They met only in Moscow, in Clinical Hospital # 6. Elvira asked him the question that tormented her for a long time: "Tolya, why are you here now, why did it happen? You were not responsible for reactor # 4, you were not obliged to work there?" Anatoliy Sitnikov answered: "Should we fail to do that, Ukraine definitely would not exist now, maybe plus a half of Europe as well. You have to understand that".

Anatoliy Sitnikov also got a lethal radiation dose. He died on May 30. In the last evening, Elvira was with her husband. It was still sunny, that hot spring day. Anatoliy suddenly asked: "Elvira, why is it so dark here?" Her heart sunk when she realised that her husband went blind ... "Tolya, you have not noticed that it is already late, that is why!" Sitnikov asked her: "Then, visit our guys also, cheer them. It is late now and you will have to wake up tomorrow at 5 a.m.". These were his last words. Even before his death he did not care of himself.

He was nominated to the title of Hero of the Soviet Union posthumously. When the list of nominees was reviewed by the CPSU Central Committee, Mikhail Gorbachev objected to awarding Anatoliy Sitnikov: "People would not understand us if we award a top manager of the Chernobyl NPP a Hero".


Aleksandr Akimov and Leonid Toptunov

Aleksandr Akimov, Leonid Toptunov, Aleksandr Kudryavtsev... Twenty three NPP staff members died and more than 150 of them got high radiation doses causing acute radiation sickness! That is the price paid for localisation of the explosion consequences...

I think that they are the most tragic persons among the personnel of the Chernobyl NPP. They were wrongly sentenced and professionally traduced by the crafty Chernobyl court process.

Some top managers of the Chernobyl NPP sacrificed them to defend themselves. First, Anatoliy Dyatlov, the chief manager of the rundown tests forced them by his orders to violate some provisions of the Test Safety Program. Then they were among the first people who launched accident mitigation works and got lethal radiation doses. In early May 1986, they died in Moscow in terrible agony, tormented by investigators of different ranks. They, forever silent, were blamed for the explosion of the reactor. Firm orders of the chief manager of the tests - as if by some magic ordeal - transformed into their discretional "unauthorised" actions and failures. These lies formed the core of the further investigation.

Leonid Toptunov, the Chief Reactor Control Engineer (CRCE) pressed the emergency shut down system button (SDS-5) as instructed by Aleksandr Akimov, the chief shift manager, after successful completion of the "rundown" test program. He made it in time, even before alarm signals "overpower" and "excess power growth rate" sounded. These facts were later confirmed by analysis of the registration tape of the diagnostic unit (DREG[2]), recording key operation parameters of Unit 4 reactor. Well, what were the reasons to qualify them as criminals?

They died without even knowing the real underlying causes of the reactor explosion. They could not even imagine that the emergency shutdown of the reactor by activation of SDS-5 button might decisively affect concealed design failures of the reactor control and safety systems, and reveal faults in physical design of the reactor.

Let us remember these people who paid by their lives for all of us...

They are still alive in our memory: "Sasha Akimov was an intelligent, educated guy. He graduated from Moscow Energy Institute. His interests were not limited to his work only, he had many different hobbies, read a lot, loved his children and cared for them affectionately... He was very proud of his children, they started to read at five, he regularly spent a lot of his time with his children and liked to tell us about them. He was very fond of his car and maintained it in a perfect order" - (Igor Kazachkov, the reactor unit shift manager).

"He was naturally inclined to follow rules" - (Aleksandr Orlenko, the Electric Section shift manager). "Akimov was a very orderly person, it was impossible to force him to violate a rule. He was very experienced" - (Boris Rogozhkin, the NPP shift manager).

Leonid Toptunov (he was 26 years old): "He was a modest person with a good theoretical background. He learned easily and liked his work" (Igor Kazachkov, the reactor unit shift manager).

Their efforts were recognised only 22 years later. By the Decree # 1156/ 2008 of the President of Ukraine of 12.12.2008, the following staff members of Chernobyl NPP who **got lethal radiation doses** were awarded **"Orders for Courage"** III grade for their personal bravery in the initial hours after the Unit 4 accident:

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[2] *Diagnostic registration of parameters*

AKIMOV Aleksandr Fedorovich - the reactor unit shift manager,
BARANOV Anatoliy Ivanovich - a chief on-duty electrician,
BRAZHNIK Vyacheslav Stepanovich - a machinist of the steam turbine of the Turbine Section (TS),
VERSHININ Yuriy Anatolievich - an engineer-inspector of turbine equipment, TS,
DEGTYARENKO Viktor Mikhailovich - on-duty operator, RS,
KONOVAL Yuriy Ivanovich - on-duty electrician, ES,
KUDRYAVTSEV Aleksandr Gennadievich - a senior engineer, RS,
NOVIK Aleksandr Vasilievich - an engineer-inspector of turbine equipment, TS,
PEREVOZCHENKO Valeriy Ivanovich - the chief shift manager, RS,
PERCHUK Konstantin Grigorievich - a senior turbine machinist, TS,
PROSKURYAKOV Viktor Vasilievich - a senior engineer, RS,
TOPTUNOV Leonid Fedorovich - a senior engineer, RS,
KHODEMCHUK Valeriy Illyich - the chief operator, RS,
SHAPOVALOV Anatoliy Ivanovich - a senior on-duty electrician, ES.

Did the NPP personnel members know about lethal radiation levels? No. Were they warned? Also no. Everyone knew that the situation is dangerous. But only a few persons knew initially that it is lethally dangerous, including the NPP Director Viktor Bryukhanov and the NPP Party Secretary Sergey Parashin. CivDef CoS Serafim Vorobyov used an Army design dosimeter DP-5 to make a few measurements at the NPP site. He reported extremely high radiation levels to the NPP Director and the Party Secretary (in some places radiation levels exceeded 2 Sv/hour). At the same time, on-duty radiation monitoring specialists did not have instruments allowing to measure radiation doses over 3.6 R/h (36 mSv/hour), and as a result, they could not provide a reliable information to operating personnel on actual radioactivity levels inside the NPP buildings. Dosimeters for higher radiation levels were locked and sealed in the emergency storage room and could not be taken from the storage without an order. Nikolay Istomin and Aleksandr Tsekalo - specialists of the Occupational Safety Department (Radiation Monitoring Service was a part the Department) - who arrived at the NPP site that night, managed to persuade Boris Shinkarenko - the deputy Chief of the Occupational Safety Department - to open the emergency storage. They took the same DP-5 dose-meters and since 4 a.m. they measured radiation levels in dangerous places in the turbine room where people worked, and in the transportation corridor under the reactor unit. Later on, Istomin and Nepiyschiy made some measurements of radioactive contamination in deaerator assembly compartments. They reported measurement results to the shift manager of the Occupational Safety Department. In his turn, he reported these data to his superiors, up to the NPP Director. Director Bryukhanov and Party Secretary Parashin remained silent, they continued to send people to lethally dangerous places without warning them on potential risks of very high radiation doses. Why? The question still remains unanswered ...

The city residents were also left without any information. Starting from 2 a.m. of April 26, the NPP CivDef CoS Serafim Vorobyov reported to the NPP Director and the Party Secretary about actual EDRs of tens and hundreds roentgen per hour on the Chernobyl NPP site, and about serious radioactive contamination (tens roentgen/hour) in some places in the city of Pripyat. He demanded emergency notification of the city residents, but his superiors merely ignored him. The Director simply drove him off. Serafim Vorobyov recalled the Director's response as follows: "He shouted 'Get out! I have Korobeynikov (the chief of the external radiation monitoring laboratory of the NPP)' and pushed me out". When he approached the Party Secretary asking for assistance, the Party Chief cowardly distanced himself from the problem "You yourself should try convincing Bryukhanov".

At 10 a.m., Viktor Bryukhanov and Vladimir Korobeynikov signed the memo note on radiation situation in Pripyat - the document listed figures in the range from 4 to 15 μR/sec (from 14 to 54 mR/hour or 0.54 mSv/hour). In any case, even after understating the real radioactive contamination levels by thousand times, the NPP top manages were supposed to notify the city residents on radiation hazards.

Besides that, the Mayor of the city, district or oblast-level Executive Committees were also obliged to launch emergency radiation notification of local residents as they fulfilled duties of Civil Defence Chiefs at territories under their control. But Ivan Stepanovich Plusch, the Chairman of the Executive Committee of Kievskaya oblast, failed to act - on that day, instead of coming to Pripyat, he went to the opposite part of the oblast. At 4:30 a.m. Vorobyov had to report the situation to Colonel Yuriy Kornyushin, the Civil Defence Chief of Staff in Kievskaya oblast. Vorobyov told him "We have a general accident here! Ge-ne-ral one! It is necessary to alert local residents!" But Kornyushin responded with a sudden sharpness: "You are an alarmist! Think what you say! I will lose my head for such a report." (Yu. Scherbak, Chernobyl).

The first days

April 26, daytime

It was very upsetting to realise that all the information from the accident zone, supplied by Serafim Vorobyov, Anatoliy Sitnikov, Aleksandr Akimov, Vladimir Chugunov, Valeriy Perevozchenko and other people, got stopped in the bunker at the level of the NPP Director, the Party Secretary and the Chief Engineer, sank in their heads and did not went any further. Naturally, I cannot claim that the highest level officials of our Chief Directorate were left uninformed, but we did not get any information. I had to gather all further information on the events independently. By 10 a.m., jointly with Anatoliy Kryat, the Chief of the Nuclear Physics Laboratory, I already visited the control room of Unit 3 and administrative and utility building # 2 (A&UB-2). I also visited the central (reactor) room of Unit 3, the control room of Unit 4, as well as premises of 5th, 7th and 8th turbine generators. I surveyed the exploded reactor unit from the NPP site. The scale of destruction was impressive. Calmly flowing water on the external (northern) wall of the destroyed reactor building looked unreal.

The destroyed reactor building of Unit 4, the view from the turbine room area (the southern part)

I will not list all orders I got that morning from the top NPP officials. I would like to focus on two particularly important ones:

- to estimate whether air cooling would be sufficient to cool the reactor (without additional destruction of fuel assemblies due to residual heat generation). At that time we already understood that the active core of the reactor was ripped open and we were not sure that water was supplied to the reactor to cool the fuel;

- to estimate the level of sub-criticality of the reactor (to what extent it was shut down by control and safety rods).

I made some calculations, based on the methodology of the Institute of the Chief Designer of RBMK Reactors. The estimates suggested that there was no sense in supplying water to the active core. If the active core was ripped open, air cooling (6 hours after the explosion) would be sufficient to prevent destruction of fuel assemblies by residual heat generated by nuclear reactions.

The sub-criticality estimates suggested that by 19 p.m. nuclear fuel in Unit 4 reactor will sufficiently de-poison from iodine and xenon to initiate uncontrolled chain reaction. In addition, the reactor might also ignite again. As control and safety rods descended to the reactor (as gauges of the unit control room suggested) on average only to a half of their height, and the reactor fuel load was at least 50 critical masses (i.e. 50 local nuclear reactors), the probability of an uncontrolled chain reaction in the nuclear fuel reached 100%.

The real situation was much worse than our estimates suggested. At that time we did not know that all control rods were blown out from the reactor together with nuclear fuel. We did not know that several hundreds of fuel assemblies mixed with graphite blocks and formed an active core debris in the reactor building, containing a critical mass of nuclear fuel (uncontrolled nuclear reactor). All preconditions for self-sustained chain reaction were present in the active core debris (nuclear fuel and moderators - graphite and water). It was just a matter of time for decay of isotopes that absorb neutrons (iodine, xenon). And the time inevitably approached.

My report to the Chief NPP Engineer and his deputy in charge of research (Mikhail Lobov) was rather short:

- water pumping to the reactor should be discontinued, because 6 hours after the reactor shut down, with its active core ripped open, air cooling of the fuel will be sufficient;
- by about 19 p.m. the reactor will depoison, therefore it is necessary to take urgent measures for its guaranteed shutdown. It is possible to use boron for the purpose, boron is a good neutron absorber, we just need to find at least a ton of boric acid and dissolve it in water. Then, the solution might be pumped to the reactor zone through fire hydrants (or by a water gun of a fire engine from the ground level, overhead, or from a helicopter);

- it is necessary to request a helicopter, call in the NPP photographer and make aerial photos of the unit and the reactor to ascertain the scale of its destruction;
- it is necessary to provide me with an armoured personnel carrier in order to establish a mobile radiation monitoring facility, allowing to register intensity of gamma, beta and neutron radiation levels in several key points on the NPP site and nearby Unit 4. The monitoring could allow us to see a dynamic picture of the process after depoisoning of the nuclear fuel, to register intensity and directions of radioactive releases in time and to obtain objective data to substantiate the decision on evacuation of Pripyat residents.

Then, I took a military issue DP-5 dosimeter from Serafim Vorobyov (the NPP Civil Defence Chief of Staff) and started surveying Unit 4 more closely. I walked around the unit at the NPP site. On the northern part of the unit I saw ripped out separator rooms, cut water pipes with water flowing out (the water apparently did not reach the reactor). I did not see any intact fuel assemblies or their fragments. I saw no graphite, only black dust. At that time I noted only garbage, soot, crashed roof plates.

In the morning of April 26, gamma radiation exposure doses at the distance of 35 to 40 m from the unit building did not exceed 50 R/hour. In the turbine room, I checked radiation levels up to turbine # 8, maximum EDR values were registered nearby turbine generator # 5 (10 R/hour or 0.1 Sv/hour), between turbine generators ## 6 and 7 (50 R/hour or 0.5 Sv/hour), nearby turbine generator # 7 (up to 100 R/hour or 1 Sv/hour), nearby the southern wall of the turbine room opposite to turbine generator # 7 (up to 200 R/hour or 2 Sv/hour), and nearby turbine generator # 8 (about 80 R/hour or 0.8 Sv/hour). The radiation source was located upper in the southern direction. In some places I saw sheets of paper hanging on wire with warning signs “Occupational Safety Department No entry!” The signs also showed radiation levels. Later on, I found that at night, around 4 a.m., Nikolay Istomin and Aleksandr Tsekalo worked there. They made measurements, placed warning signs, drew a chart of indoor radioactive contamination and reported their findings to superiors. Why had that information been “buried” at the level of the NPP top officials? Why did not they display the chart in the Civil Defence HQ? Why did the Director and the Party Secretary continue to keep the personnel in the dark, why at 10 a.m. did they report “to the upper level” radiation levels understated by several thousand times? These questions permanently trouble me.

I visited Unit 4 Control Room to see for myself that control rods did not descend completely as the synchro gauges suggested, but I did not record their values, as I was in a hurry. I just noted that all control rods were inserted into the reactor just for about a half of their length. A little later that day, a senior CSS master of TICS[3] Eduard Petrenko recorded all synchro gauge values. Using these data, jointly with Anatoliy Kryat we once again tried to persuade the NPP top officials that a potential disaster is possible in the reactor if we fail to add boron. I based my conclusions on the assumption that the critical layer (that might behave as an independent local nuclear reactor) in the RBMK reactor is of a size a little bit under 1 metre in height - as a result, the bottom section of the reactor, that was not penetrated by safety rods and contained several critical masses, might become a delayed action bomb - a nuclear reactor of uncontrolled power output.

For the whole day, I myself, Anatoliy Kryat and Aleksandr Gobov repeatedly warned on the threat deputy Chief Engineer Mikhail Lyutov, Chief Engineer Nikolay Fomin and - via the Party Secretary Sergey Parashin - the NPP Director Viktor Bryukhanov. According to Parashin, the Director requested boric acid, but it was not delivered to the NPP on April 26. Later on, we found that "specialists" from the Governmental Commission decided to deliver boron by the truck but the cargo finally arrived there only a day later. The time for "calming" the reactor was lost irrevocably. I could hardly imagine a higher professional improvidence...

I particularly acutely felt the inability to secure the damaged reactor reliably from the development of uncontrolled chain reaction, because totally unprotected residents of Pripyat, including my own family I was seriously worried about, still remained in the city. It was absolutely clear that in the evening the reactor will inevitably "come back to life", even if the explosion had thrown the whole of its fuel load into the reactor room. As I already said, the standard fuel load of the reactor contained at least 50 critical masses, meaning that in the evening, the NPP site and the city would be attacked by radiation of unprecedented intensity, like under a neutron bomb explosion. It was necessary to prepare for evacuation of the city residents, this was absolutely clear to all specialists and we started to inform the NPP top officials on the matter. Their response was hardly promising. As for evacuation of the city residents, the NPP Director said that he is not authorised to make such a decision (according to the applicable regulations, the NPP Director was the supreme authority on Civil Defence matters and had necessary authority to order evacuation). After such a response we realised that we cannot hope for adequate actions of the top officials any more, and we could rely on ourselves only.

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[3] *Thermal Instrumentation and Control Section*

Initial radiation monitoring results

Our Nuclear Safety department was represented in the command bunker by Vitaliy Perminov (the Chief of the Spectrometry Laboratory) and his deputy Anatoliy Sukhetskiy. They were called to the site with the morning shift. They collected samples of water and fallout nearby Unit 4 and tried to conduct their spectroscopic analysis. Their attempt failed, as the background radiation level was too high. They had to sent home laboratory technicians Aleksandra Istomina and Valentina Umnova, who were earlier called to the NPP site. Unfortunately, while staying on the site, the women got substantial radionuclide contamination that caused a lot of troubles for them later on. After their evacuation from Pripyat, while they tried to reach their relatives, they were many times stopped by radiometry posts in airports and railway terminals due to high radiation levels. Radiometry posts personnel demanded them to change into clean clothes (they naturally did not have any) …

Anyway, the samples were analysed eventually. After assembling a “chamber” of lead bricks and installing the spectrometer detector inside, the background radiation was cut-off and the spectrometer started to produce reliable results. After the midday, Perminov told me some specific facts revealing the real scale of destruciton of the reactor. Spectrometric analysis of the fallout samples suggested presence of fission products, while neptunium generated 17% of the overall gamma radiation intensity - these findings clearly suggested that the active core of the reactor was destroyed and fuel particles were released to the ambient air. Nuclear fuel particles were identified in all samples (air, dust and water). Radioactive contamination of the water that entered Unit 4 building and then flew to lower levels of the NPP reached 10^{-3} Ci/litre. These data convinced us that Unit 4 reactor was severely damaged. The spectrometry results were immediately reported to the NPP top managers - to Lyutov, and then to Bryukhanov and Parashin.

The radionuclide-contaminated water caused later a substantial harm to all persons who contacted it. Personnel members who had no access to reliable radiation monitoring information in the initial hours of the accident and who were not timely sent by radiation monitors to decontamination washing facilities for showering and changing into clean coveralls, were doomed to radiation burns and acute radiation sickness. Contaminated clothes generated 1-2 Sv/hour even after one’s return from a dangerous place to a cleaner location. Many people suffered as a result, in this connection, the example of excessive radiation exposure of Aleksandr Nekhayev (the chief mechanic engineer of RS-1) is particularly illustrative. Boris Rogozhkin, the chief NPP shift manager, sent him to Unit 4 after the explosion, to assist the chief Unit 4 shift manager Aleksandr Akimov. Jointly with Akimov and Leonid Toptunov (CRCE of Unit 4) they manually turned valves in the feedwater installation room, partially destroyed by the explosion, under falling radioactive water flows (according to measurements made later, the water's radioactivity was found to exceed 1 Sv/hour). When he finally returned to his workplace, he had no time to visit a decontamination facility to wash and change into clean and dry coveralls, when he was again ordered by the chief manager of RS-1 Vladimir Chugunov to return to Unit 4. Nekhayev failed to explain Chugunov that he had just returned from Unit 4 and needed to wash radioactive dirt and change into clean clothes. He was resolutely ordered to join Chugunov's team. Nekhayev was not even allowed to make a phone call to his wife …

Vladimir Chugunov and Anatoliy Sitnikov were called to the NPP site by the NPP Director. He and the NPP Party Secretary Sergey Parashin ordered them to perform a task in Unit 4, but did not inform them on extremely high radiation levels inside the unit building. Maybe this was the reason why Vladimir Chugunov did not allow Aleksandr Nekhayev to the decontamination facility, considering his request ill-timed… They went to Unit 4 accompanied by Chugunov's deputy Vyacheslav Orlov and the chief RS manager Arkadiy Uskov. Finally, all of them got acute radiation sickness. Alatoliy Sitnikov died a month later, while Nekhayev, who reached the decontamination facility only by 9 a.m., in addition to radiation sickness suffered also severe radiation burns and persistent wounds on his body and legs. He underwent 14 major skin graftings, but medics finally failed to save one of his legs. A year after the accident he had one of his legs amputated.

He is a man of great moral courage! I had many opportunities to see how he fought his health troubles, several times our hospital beds were placed near in many different clinics and hospitals. He never surrendered to pain and frustration of helpless medical treatment, in the most crucial moments of his life he always managed to joke and make interesting reflections. I am grateful to him for such a great exemplification of human resilience!

The family

Immediately after getting information on presence of nuclear fuel particles in the air, I made a phone call home to my wife. I asked her to close windows, to avoid going outdoors, assemble a small bag with children's belongings and wait for my return. I thought how I could remove my family from the city before the evening, before the reactor will "wake up"? Having completed the most urgent tasks, I asked the NPP Director to provide a bus for personnel to go to the city for lunch.

The director provided the bus. Beforehand I agreed with Anatoliy Kryat that instead of the lunch he will assist me to transfer my family in his car to our relatives in the city of Chernobyl (12 km from Pripyat). I made phone calls to the Chernobyl relatives and to my wife, asking them to be ready. At about 14 p.m., we boarded Anatoliy's car, arrived nearby my house, took my family and headed to Chernobyl. At the exit road from Pripyat, at the bridge over the railway line, we were stopped by an armed Militia officer who ordered us to return to the city. We found that all exit routes from the city were blocked by Militia on request of the authorities, in order to prevent spontaneous flight of local residents to prevent panic spreading. I realised that they wanted to make us hostages of the situation and was outraged. The Militia officer advised me to settle the matter in the city Militia Department. We had to go to the Department. In the Militia Department building we saw a lot of MoI officers who hurriedly circulated inside, including high rank MoI officers from Kiev among them. Was I of any interest to anyone of them with my minor personal problem? No chance! But suddenly I recognised Militia Captain Vyacheslav Vasheka among them, like me, he also was from Urals region. He was also mixed up but came to me. Having no hopes for success, I quickly explained him the situation and asked to escort us to Chernobyl. He did not refer to the order prohibiting residents to flee the city. He did not excuse himself by urgent tasks from his superiors. He simply agreed to help me, unconditionally, because he was a real man... Besides, he hoped to hear about details of the NPP accident from me in the voyage.

We again approached the Militia checkpoint, they again tried to stop us, but this time Captain Slava who sat near the car driver simply instructed the checkpoint Militia officer to go to Hell and we continued our journey.

Having dropped my family near the house in Chernobyl, I hardly had time to embrace my pale wife, one year old daughter and three years old son who also felt that that the situation is unusual. I did not know when I could see them again and whether we would ever meet, as I had to return to the hell and do the work I planned to complete myself that day... But now I was free of fears about my family and I could focus on my work completely. So, we hurriedly returned to Pripyat, delivered Slava to the city Militia Department and went to the NPP site. I disclose this episode for the first time. I am very thankful to Slava Vasheka, a great man and a decent Militia officer who died in his early years. His heart really ached for all of us and finally his heart stopped…

After our return to Pripyat we divided. Slava returned to his service duties, Tolya Kryat drove his car to a garage, while I hurriedly run to the NPP site, where I expected to board a helicopter I requested earlier to survey the exploded reactor unit from the air. That time, I did not see

Militia officers in the forest strip separating the NPP site from the city. But I encountered several groups of children who came to see the destroyed reactor unit. I quickly explained them that staying in the open air is dangerous and urged them to return home.

I arrived in the underground bunker at the NPP site at about 15:30. I was a few minutes late to board the helicopter that was already in the air heading to Unit 4. The helicopter carried the NPP photographer Anatoliy Rasskazov and a representative of the Chief Designer of RBMK reactors Konstantin Polushkin. It was a pity that I was late to board it. Anyway I started to prepare a mobile radiation team to monitor changes in radiation levels after depoisoning of the nuclear fuel.

The evening nightmare

The list below shows my morning recommendations to the NPP top officials, followed up or otherwise:

- as high officials of our Ministry insisted, water was supplied to the active core of the reactor for the whole day;
- no additional neutron adsorbers were added to the reactor as the boron cargo was not delivered to the NPP site;
- a helicopter I asked for was provided but when it landed I was running to the NPP site from Pripyat. They looked for me but decided not to wait. The helicopter took Konstantin Polushkin (from NIKIET[4]) and Anatoliy Rasskazov, the NPP photographer who was called to the NPP site that day. They make some photos of the destroyed reactor unit but did not show the photos to us;
- they provided us an armoured personnel carrier as I requested. Jointly with Yuriy Abramov (the shift manager of the Occupational Safety Dept.) and the APC crew, from 16:00 we started to run along the same route every two hours and take measurements in the same points (5 measurement points in total). We had instruments to measure gamma, beta and neutron radiation.

In the course of our rides we saw that water from fractured pipes flew down along the northern wall of the unit building (the water was supplied to cool the reactor). Dissolving fission products and fuel particles in the run, the water then flew from lower levels of Unit 4 constructions to units ## 3,2,1 and contaminated the NPP interior. The daily shift personnel pumped the water out. On April 26, 10 thousand m^3 of water were pumped to the reactor without any effect and only contaminating the NPP site further. I was not the only person who

[4] *The USSR R&D Institute of Power Engineering*

informed the NPP top officials that water did not reach the reactor, many other people who also assessed the scale of the destruction told them the same, including the deputy chief of CRS (Centralised Repairs Section) Yuriy Yudin, the chief unit shift manager Vladimir Babichev, Viktor Smagin, Anatoliy Kryat and others.

The nuclear fuel depoisoned as estimated and at about 20:00 we registered a fire in the reactor unit, with periodical loud explosions. Initially, the upper part of the unit construction got illuminated by ruby-red glow from inside, then candescent light and flame flashes followed of dazzle white colour - such flame is produced by burning metal uranium. The flame cones irregularly pulsed from the foundation of the ventilation stack up to the whole its height (150 m), as if something fuelled them from inside (like water pulses in a geyser). We noted that the flame cones were of irregular height in different parts of the destroyed reactor room, suggesting that several flame sources were present with different intensity; the fire was accompanied by sounds of different tone and intensity - from loud rumble to volcano-like explosions. The fire was so intensive that any attempts to extinguish it were futile. It was impossible to come closer to the fire, anyway, nobody had even attempted to extinguish it. By that time, no firefighters were present at the NPP site, almost all firefighters of Kievskaya oblast got radiation doses in the previous night and were out of operation. It would be an absolute madness to send people to that hell on Earth.

Radioactive releases from the unit immediately started to rise, and we started to register growing radiation intensity in our measurement points. We made our last measurement trip at 24:00 of April 26, by that time (after 4 hours of fire), gamma radiation intensity increased more than ten-fold and Yuriy Abramov for the first time registered neutrons over the sensitivity threshold of RUP-1 radiation meter instrument. In the course of our initial measurements, the instrument registered 3 neutron/sec/cm^2, then 5 and 7. In the course of our last measurement trip that day, in the point opposite to the northern part of Unit 4 construction we registered 20 neutron/sec/cm^2. To tell the truth, I expected a much graver situation, resembling something like a neutron bomb explosion. When I returned to the bunker, I even told Anatoliy Kryat that my worst expectation fortunately failed to materialise.

At 24:00 of April 26, in the last measurement point of our monitoring route (the point opposite the northern part of Unit 4), at the initial EDR (exposure dose rate) in the morning - day of 200 mSv/hour, EDR reached 2 Sv/hour. The data clearly confirmed that, after 19:00 of April 26, a self-sustained chain reaction started in the depoisoned nuclear fuel. As we ascertained later, all the fuel from the active reactor core was blown out but some part of it remained inside the damaged reactor room - that part formed a pulse nuclear reactor that generated power pulses when reached critical conditions. These power pulses were decisively influenced by continuous inflow of water to the damaged multipass forced circulation circuit (MFCC) and lack of neutron adsorbers in fuel-containing masses. We could avoid such a disastrous aggravation of the accident should we deliver a neutron adsorber - boron - to the site timely. But boron was not delivered… As a result, the new day of April 27 did not promise us any improvement, it was time to put the NPP out of operation urgently. The third unit had been already shut down, it was time to shut down units ## 1 and 2. These units were shut down on early hours of April 27 (Unit 2 at 1:13 and Unit 2 at 2:13).

Uncontrolled pulse nuclear chain reaction in the damaged unit died out at about 4 a.m. of April 27. By that time, the local critical mass had already exhausted its “capacity”. However, later on, for almost two week (especially after covering the debris by clay, sand, lead and boron) major releases of heat and radioactive gases were registered there.

After our monitoring voyages we returned to the bunker and reported measurement results to Bryukhanov and Fomin, who, in their turn, called members of the Governmental Commission who stayed in Pripyat.

Shortly after the midnight, our work was finished and we went to Pripyat to sleep in our flats. We were completely exhausted, but nobody was able to relieve severe nervous excitement. We understood that the city was already doomed. However, we also knew that the worst things at the NPP site had already happened.

The city under the radiation attack lived as usual. The Governmental Commission from Moscow arrived and worked in the hotel. The authorities did not publish official information for the population on radiation hazards associated with the accident, thyroid protection pills were issued only to some residents and only in some locations. That was the second criminal fault of the officials in charge of the accident localisation works, who took no measures to protect the city residents (I think that their first fault was associated with underestimated significance of timely introduction of the neutron adsorber (boron) into the fuel-containing debris and the reactor shaft - the fault that catastrophically aggravated global impacts of the accident).

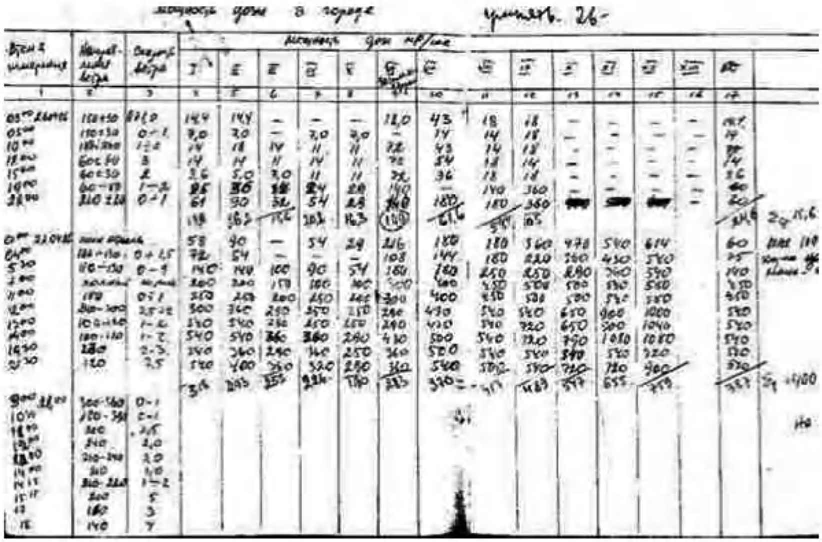
Why did the authorities fail to act? First, they simply were not prepared to deal with the accidents of such a huge scale, notwithstanding their regular participation in Civil Defence drills. Second, they feared to made decisions and assume responsibility for them. And third, they did not care of people. It took some time before I came to such depressing conclusions, for a long time I analysed actions of authorities of different levels (party and administrative authorities alike, from the local level to the highest levels). But now, a quarter of century after the Chernobyl explosion, I am absolutely sure. And I am not the only person who shares that view. Serafim Vorobyov, the Chief of Staff of the NPP Civil Defence, answered the above question in such a way: "in a few hours after the explosion, the second oblast-level Party Secretary Vladimir Grigorievich Malomuzh arrived in Pripyat. He was the person who had taken command. I assess him as a sensible party chief, he sincerely worried about all the developments there, but Civil Defence was outside his professional competence. These matters are associated with multiple important details. Before one tries to look deeper, things seem simple, but a deeper insight into specific matters may puzzle one... Such a situation did happen at that time: it was necessary to decide, but they were not sure that their decisions are correct, so they started to wait for instructions from above, trying to shift the burden of responsibility onto more and more higher officials. A lot of them arrived in Pripyat later on! They included General Bondarchuk, the Civil Defence Chief of Staff of Ukraine, and General Ivanov, the deputy Chief of the USSR Civil Defence Command. When I heard about their arrival, I thought 'At last, everything will be settled!', but... I still wander why they did not alert the population that time".

I have to add from myself, that by the evening of April 26, the supreme command of the situation was taken by the Governmental Commission led by Boris Evdokimovich Scherbina, the deputy Chairman of the Council of Ministers of the USSR. An agenda item the Commission initially planned to review on that day (but rather quickly abandoned) clearly reveals how well the Commission members were aware of the actual situation - they planned to review a schedule of repairs and decommissioning of Unit 4 destroyed by the explosion. On April 26, the Commission had failed to address such problems as alerting the city residents on local radioactive contamination, injecting boron into the reactor, protection and timely evacuation of the city residents. The city was evacuated only 36 hour after the reactor explosion.

Radiation situation in the city of Pripyat

Weather conditions in the city on April 26 may be described as calm. The reactor continuously released radionuclides, as a result, the radiation situation the Pripyat located nearby the Chernobyl NPP site (at the distance of 3 km) gradually worsened.

The below scanned page from a log book provides results of measurements made in the city of Pripyat by radiation monitors from the NPP External Radiation Monitoring Dept. on April 26, 27 and 28, 1986.

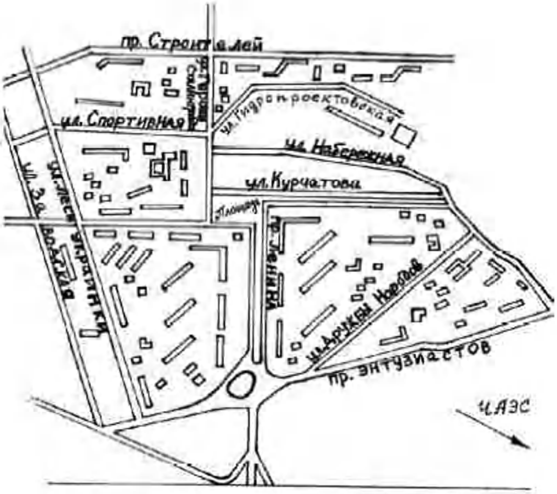


Gamma radiation EDRs (exposure dose rates) are presented in mR/hour (1 mR = 10 μSv).

Notes:

- *the table does not contain information on "hot spots" of radioactive contamination (0.02 Sv/hour or higher) that were identified in the city in the morning of April 26;*
- *the maximal annual radiation dose threshold for personnel members of key NPP sections was set at the level of 0.05 Sv/year; any Pripyat child could accumulate the dose by a couple of hours while being outdoors.*

The table below provides the same information but associated with specific streets of the city:



The outline map of the city.

Photo of Pripyat. The shorefront view.

The shorefront (Naberezhnaya St.) was the most heavily polluted place in the city (and the most popular place among the city residents).

Pripyat streets	Average gamma radiation EDRsя		Max. gamma radiation EDRs	
	26.04.1986	27.04.1986	26.04.1986	27.04.1986
Kurchatova St.	220 μSv/hour	3200 μSv/hour	900 μSv/hour	5400 μSv/hour
Sportivnaya St.	160 μSv/hour	2500 μSv/hour	320 μSv/hour	3800 μSv/hour
Gidroproektovskaya St.	200 μSv/hour	2300 μSv/hour	540 μSv/hour	4000 μSv/hour
The City Square	860 μSv/hour	2800 μSv/hour	1400 μSv/hour	4300 μSv/hour
Druzhby Narodov St.	620 μSv/hour	3800 μSv/hour	1800 μSv/hour	5400 μSv/hour
Entuziastov St.	530 μSv/hour	5200 μSv/hour	3600 μSv/hour	10400 μSv/hour
Naberezhnaya St.	1200 μSv/hour	7600 μSv/hour	3600 μSv/hour	10800 μSv/hour

The Table shows that <u>radiation levels in the city sharply increased after depoisoning of the reactor (after 19:00), when uncontrolled nuclear reactions started in the nuclear fuel</u>. By the moment of evacuation (14:00 of April 27), intensity of gamma radiation almost in the whole city varied from 5 to 10 mSv/hour. In some places it was up to 100 mSv/hour or even higher. This means that Pripyat residents accumulated several annual doses of a professional NPP worker (about 0.20 Gy at average). These figures do not account for high internal radiation doses associated with inhaled radioactive gases and dust. As Leonid Khamyanov (the Chief of Radiation Safety and Chemical Technology Processes Dept. of VNIIAES[5], who worked with the Governmental Commission) admitted later in his memo "Assessment of Radiation Consequences of the Chernobyl NPP Accident": "The inhaled dose load on thyroid gland in the course of the cloud passage after the initial release reached about 10 Gy for children in the city of Pripyat at the distance of 3 km... " (L.P. Khamyanov. Chernobyl. The Radiation Situation in Initial Days, in "Moscow to Chernobyl" monograph - M., 1998.)

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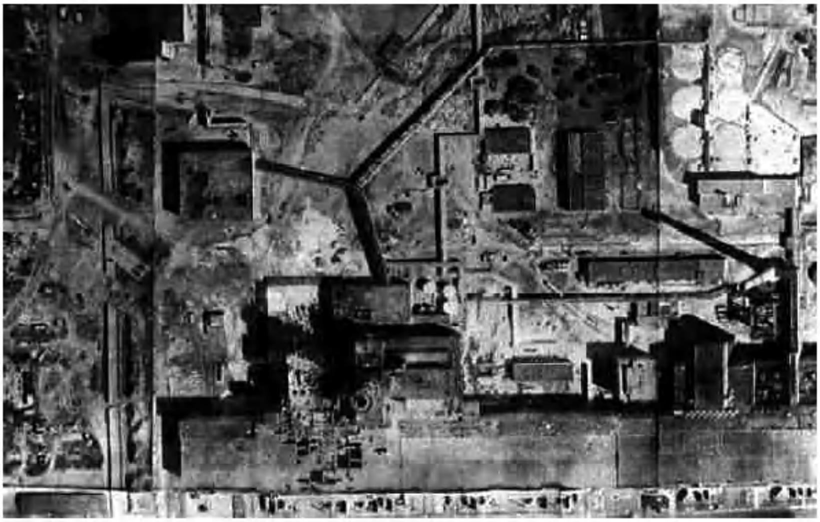
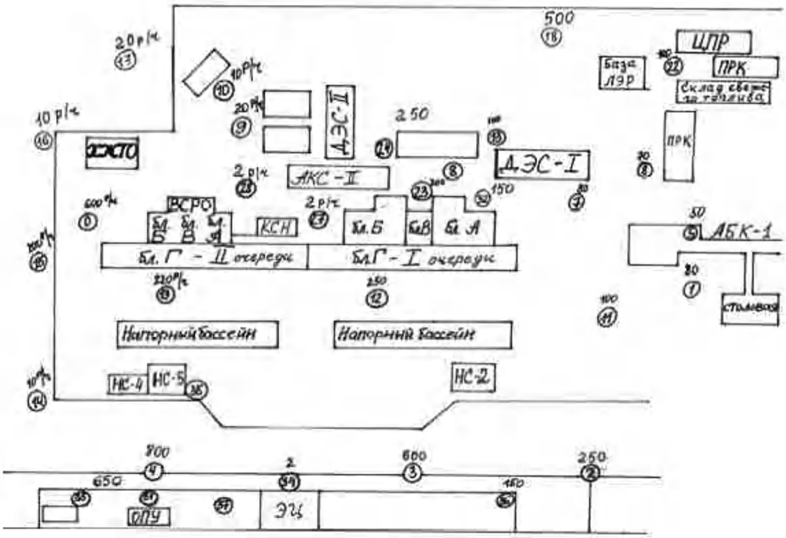
[5] *The USSR R&D Institute of NPP Operation*

Photo of the Chernobyl NPP. The long turbine room building is visible on the forefront. Black reactor unit buildings are located behind it. The double building of reactor units ## 3 and 4 is located behind the left part of the turbine building (with the 150 m high ventilation stack between the units). The city of Pripyat is visible in the right upper corner of the photo.

The outline chart below contains radiation intensity data for the Chernobyl NPP site on 26.04.86 before the evening fire at Unit 4.



The aerial photo of the Chernobyl NPP site (the turbine building is the longest grey building in the bottom part of the photo).



The outline chart of the Chernobyl NPP site

Note: *figures without measurement units represent EDRs in mR/hour (miliroentgen per hour). Exposure dose rates in the most heavily contaminated places are provided in R/hour. 100 R/hour = 1 Sv/hour.*

By the way, Boris Scherbina, the deputy Chairman of the USSR Council of Ministers, Yuriy Izrael, the Chairman of the USSR State Committee for Hydrometeorology and his deputy Yuriy Sedunov, at the press-conference in Moscow on May 6, 1986, claimed that radiation intensity nearby the damaged reactor unit of the Chernobyl NPP reached merely 150 μSv/hour! Actual EDRs at the NPP site varied from 0.05 to 3 Sv/hour. In some places EDRs reached up to 10 Sv/hour and even higher. In the city of Pripyat and nearby the city, EDRs varied from 10 to 30 mSv/hour, while in some places EDRs were up to 500 mSv/hour.

April 27 works

I did not see what happened in Pripyat that morning as I went to the NPP site very early. I did not see how the city residents were evacuated at last (but already too late) at the daytime. Later I got information that the Ministry of Road Transport of UkrSSR was instructed by the UkrSSR Council of Ministers to start moving bus convoys from Kiev to Chernobyl at 23:25 of April 26. By 4 a.m. of April 27, 1125 buses, 250 trucks and specialised vehicles were in full readiness nearby the city of Chernobyl. The transport authorities were ordered to start evacuating people at 13:30 of April 27 (The Chernobyl Tragedy. Documents and Materials, p. 80).

The NPP physicists focused on lay-up of the already shut down reactors of units ## 1, 2 and 3, unloading nuclear fuel from tens of reactor channels and installing additional neutron-adsorbing rods into the channels emptied. We spent the whole day to these operations. Besides that, we drafted a list of the personnel necessary for operations in the incoming days. All others were allowed to evacuate with their families.

Operators worked in unit control centres, people continued to work in the turbine room notwithstanding rather high radiation levels nearby turbine generators ## 7 and 8 (up to 1.0 Sv/hour). We worked up to 24:00 and then the NPP bus moved us to the empty city, patrolled by Militia officers without any protective gear. When they saw us they requested us to show our documents and then started to ask us how dangerous staying in Pripyat is. We advised them to minimise staying in the open and to protect lungs by respirator face masks.

Dark houses with their windows unlit gave an unusual impression. Almost all residents were evacuated, only the necessary minimal workforce (about 200 people) were left to maintain safety of idle reactor units and associated machinery.

April 28

Physicists of our Radiation Safety Dept. worked all the subsequent days, transferring reactors ## 1, 2 and 3 into a nuclear-safe state and continuing to sleep in their city flats. That morning, while approaching the bus stop to go to work we saw helicopters with bags on external load slings that dropped their load onto Unit 4 (sand, lead, dolomite). When the load hit the reactor room opening a dust cloud emerged from it, resembling a weightless silk scarf. The “scarf” then expanded, grew much larger and slowly moved towards the city. It is nothing surprising that, later on, the city of Pripyat has not been washed from radiation, the city area is still contaminated by hazardous uranium and plutonium isotopes in excess of all imaginable standards.

Only on May 4 we were relocated to “Skazochniy” children’s summer camp located at the distance of ten kilometres from Chernobyl (22 km m the NPP site) - all the remaining NPP personnel were resettled to the camp. By that time, due to the southward change of the wind direction, radiation levels in the camp increased and reached up to 20 μSv/hour, or about 100 times higher than the pre-accident background level. However, in Pripyat, radiation levels reached hundreds millisieverts per hour, and we had no other option to relocate the personnel.

The area in front of the sanitary checkpoint established by the NPP radiation monitors at the entry to the camp looked rather strange. It was clear that before us a lot of other people were already admitted to the camp - the ground was covered by heaps of contaminated footwear, and clothing items that were not yet removed for utilisation, hanged at branches of trees, like X-mas toys. We also arrived in our casual everyday clothes we wore at work and in our Pripyat flats. All of us were checked by a radiation meter. My sport shoes were contaminated to 50 mSv/h, clothes - up to 10 to 30 mSv/h. All other members of our group were similarly contaminated. We all had to remove all our clothes, men and women alike. In such a way, we crossed another line, as after a shower we did not use ordinary clothes and shoes for a long time. We all were issued coveralls and white surgical boots as footwear. We wore them for the whole period of several long months while working and living in “Skazochniy” former summer camp, and then in “White Steamers” and in the new “Green Cape” townsite for the NPP personnel.

April 29

For the first time, I managed to make a phone call from the NPP site to my family in Chernobyl. They saw a huge bus convoy with evacuated Pripyat residents, to my wife the convoy reminded heart-breaking documentary WW2 footage.

Life in Chernobyl continued as usual, but the city was also seriously contaminated by radiation and its residents also faced prospects of inevitable evacuation. I asked my wife to go farther from the Chernobyl NPP, to Kiev, a safer place for our children. She did it, but with a some delay. Only by May 1, my family reached the capital city and they were accommodated by Irina, my wife's sister, who accepted them with love and warmth.

Was Kiev safe that time, particularly after the change of prevailing winds that started to blow from Chernobyl towards Kiev, and after arrival of tens of thousands of contaminated vehicles from radiation-affected areas? Newspapers reported that Kiev is clean. Soviet TV channels also calmed. However, foreign media outlets reported that radioactive fallout polluted large areas in the majority of European countries. I simply could not believe that Kiev might remain clean, as the city was located at the distance of just 100 km from the exploded reactor. So, I made all possible effort to send my family from Ukraine, and I got assistance from our trade union. Due to the trade union's support, by early June my family went to Dnestrovsk (Moldova) and stayed in the trade union sanatorium of Moldova SDPP, till mid-September 1986.

Kiev

According to all official Soviet information sources, Kiev was not affected by radiation. The city was considered "clean", authorities conducted a major May 1 demonstration and allowed to carry an international bicycle rally on May 6 to 9. So, for some obscure reason, radioactive substances jumped over the ancient city and deposited only far away, in southern regions of Ukraine. I did not believe in such miracles and later on my suspicions about serious radioactive contamination of Kiev were confirmed. Just two facts from a long range of evidence: in June 1986, Nikolay Tarakanov, who is now a Major General (in reserve) of the Civil Defence Command, addressed the problem among other things. As he told me later, the story started when "one curious Colonel, Doct. of Sciences Kaurov, when we almost completed our operations (they conducted decontamination of the Chernobyl NPP site, and removed sources of ionising radiation from roofs - N.K.), delivered several chestnut leaves collected at Kreschatik St. (the central street of Kiev - N.K.) and stored then in a safe in absolute darkness. A few days later he removed the leaves from the safe: the leaves were still green but they were all pitted, as if moth-eaten. We assembled a group of 1400 officers (in addition to research personnel) and at night, to avoid frightening Kiev residents, they visited Kiev and collected tens of thousands of samples. Then we arranged a flight and sent all the samples to Semipalatinsk Nuclear Test Site. A week later we got the measurement results, suggesting that radioactive contamination in Kiev was tens of times higher than officially reported". (Chernobyl. Eye-witnesses Reports and Scientific Forecasts. 2004).

What happened next? They started to wash and clean the city, with unprecedented frequency and for a long time. As General Tarakanov wrote: "I will remember that to my death - Kiev was washed thirty three times, all vegetation at all streets and crossroads was removed, sealed into PE bags and disposed onto 10 burial sites around Chernobyl".

Had that large-scale operation resolved the problem of radioactive contamination of Kiev? Yes, but only partly. Roads, squares, building walls and pavements were washed out, but only temporarily. It is clear, that even a thousand divisions of soldiers and janitors would not suffice to filter and decontaminate many billions of cubic metres of radiation-impregnated air flows that cross Kiev all the day round, for weeks and months. Radioactive contents of these air flows continuously deposited at all surfaces they encountered in the run, including lungs of Kiev residents.

The second fact is disclosed in document "Radiation Situation Forecast for Kiev to the Nearest 10 Years" that was produced on request of Boris Paton, the President of the Academy of Sciences of Ukraine. The document was drafted by A.F. Linev, a Research Associate of the Institute of Nuclear Research of the UkrSSR Acad. Sci. The document is dated 25.06.1986 (a copy of the document is exhibited in Chernobyl National Museum in Kiev and it is accessible to anyone). The Forecast suggests that in the first year after the accident an average Kiev resident is expected to accumulate 20 rem (roentgen equivalent man). The second year will add 9 rem, the third - 2 rem, while the tenth one will add 1 rem. So, in 10 years, the minimal exposure was expected to reach forty rems (20 + 9 + 2 + 1.8 + 1.6 + 1.4 + 1.3 + 1.2 + 1.1 +1.0 = 40.1 R or 0.4 Sv). The latter figure corresponds to eight maximal annual radiation exposure doses of professional nuclear power industry workers (who are to be healthy persons by definition). But Kiev residents, like residents of any other city, included children and adults, healthy and ill ones...

Note:

To do justice, it is necessary to note that later (in 1992) a criminal case was initiated against representatives of highest Ukrainian authorities for deception of their own peoples. The criminal case was initiated on February 11, 1992, against highest Ukrainian officials - the First Secretary of the Central Committee of the Communist Party of Ukraine Vladimir Scherbitskiy, the Chairman of the UkrSSR Council of

Ministers Aleksandr Lyashko, the Chair of the Presidium of the UkrSSR Supreme Council Valentina Shevchenko and the Public Health Minister of Ukraine Anatoliy Romanenko.

On April 24, 1993, O. Kuzmak, the Investigator in charge of particularly important cases of the Office of the Prosecutor General of Ukraine, a Senior Counsellor of Justice, issued the following statement on results of review of file materials of Case # 49-441:

“This criminal case was initiated on February 11, 1992 in connection with actions of officials of state and public bodies in the course of the accident that happened on April 26, 1986 at the Chernobyl NPP and mitigation of its consequences, based on elements of crime under papa 2 of Article 165 of the Criminal Code of Ukraine (abuse of official powers or abuse of office). The criminal case was initiated on the base of materials of the temporary Commission of the Supreme Council of Ukraine for investigation of the whole set of events associated with the Chernobyl NPP accident, that were submitted to the Office of the Prosecutor General of Ukraine”.

The criminal case contained a sufficient body of evidence to award a deserved punishment to the highest representatives of authorities.

Extracts from case file materials of Criminal Case # 49-441: “On April 30, 1986, the deputy Minister of Public Health of the UkrSSR A.N. Kasyanenko informed the Council of Ministers of Ukraine, that a sharp increase of gamma radiation intensity was registered in Kiev - from 0.5 μSv/hour to 11 - 30 μSv/hour - in Dneprovskiy and Podolskiy districts of the city and in the central part of Kiev. Levels of radioactive contamination of soil samples collected in Polesskiy, Chernobylskiy and Ivankovskiy districts varied from 100 to 200 μSv/hour.

Contamination of drinking water and surface water bodies was identified. In other districts of Kievskaya oblast, intensity of gamma radiation was found to increase in 2-3-5 times. Background gamma radiation intensity was found to increase up to 1.4 - 1.5 μSv/hour in Rovenskaya, Lvovskaya, Zhitomirskaya, Kirovogradskaya and Cherkasskya oblasts.

While providing these confidential data, Kasyanenko recommended the Council of Ministers of Ukraine to alert residents of Kiev and Kievskaya oblast on the radiation hazards immediately. However, Lyasko, Scherbitskiy and Shevchenko who had that information, failed to inform residents of Kiev and the oblast on the radioactive contamination and the necessary precautions, they concealed information on these hazards, failed to take measures for cancellation of the May 1 demonstration, that facilitated excessive radiation exposure of people”.

After seven years of procrastination, the Office of the Prosecutor General of (now independent) Ukraine ruled that the key decisionmakers of the former UkrSSR plus the former Public Health Minister A. Romanenko "cared of their own well-being and official careers", "abused their official powers and office, that resulted in grave consequences" ..."guilt of Scherbitskiy, Shevchenko, Lyashko and Romanenko... has been proven". However, nobody was punished… due to expiration of liability terms (The Chernobyl Tragedy. Documents and Materials. Kiev, Naukova Dumka, 1996, p. 691).

As it usually happens, a criminal case against highest authorities failed to achieve anything. They just managed to release public anger safely.

By that time, V.V. Scherbitskiy, the First Secretary of the Central Committee of the Communist Party of Ukraine was already dead (he died in 1990).

A pensioner A.P. Lyashko, who headed the Government of Ukraine for 15 years (1972 - 1989), was let up, maybe for ethical reasons.

The Chair of the Supreme Council of Ukraine V.S. Shevchenko was also left unhurt. In 1990s she chaired the National Fund (Ukraine for Children), the National Charity Fund to Support Development of Physical Culture, Sport and Tourism. Since 2002, she chaired the Congress of Business Women of Ukraine. She was awarded for her work by the Order of Princess Olga 2nd grage (March 5, 2005) and the Order of Prince Yaroslav the Wise 5th grade (March 4, 2010) - *for her substantial personal contribution into socio-economic and cultural development of Ukraine, active public work, many years of conscientious labour efforts and in connection with the International Day of Women's Rights and Peace*.

Former Chairman of Kievskaya oblast Council I.S. Plusch, who was a witness in the criminal case, was elected the Chairman of the Supreme Council in 2000 and then was awarded the title of Hero of Ukraine in 2001.

The Chairman of Kiev city Council, V.A. Zgurskiy (who already was a Honourable Radioman of the USSR, a Honourable Inventor of the USSR and a Honourable Railwayman of the USSR) was awarded a Honourable Citizen of Kiev in 1997. After the accident he was awarded the Order of Bogran Khmelnitskiy 3rd grade (2000) the Order for Courage (1999), and medals. Now he is a pensioner, but he still chairs the Supervisory Board of "Dimano-Kiev Soccer Club" Co.

The country got strained

Individual dose monitoring

By early May, our works at the Chernobyl NPP site got a regular pattern. Duty shifts personnel controlled operational equipment of shutdown reactor units. The shift personnel were transported to the site in armoured personnel carriers. Members of other units organised their workplaces in “Skazochniy” camp. In particular, the laboratory of individual dose load monitoring was established there and started to operate. To a large extent, the launch of the laboratory was ensured by Nikolay Istomin and Leonid Vorobyov from the Occupational Safety Dept. The problem was associated with the fact that individual photo registers that were used for radiation exposure dose monitoring had the upper limit of adsorbed gamma radiation of 0.02 Gy. It was sufficient in the course of standard operation of the NPP, but it was clearly inadequate in the new situation, when a new after-accident upper dose limit was set for all persons who worked in the Chernobyl NPP zone - 0.25 Gy. The problem might be resolved by application of KDT-02 thermoluminescence-based meters that were purchased earlier for personnel of units ## 5 and 6 of the Chernobyl NPP (the ones under construction). However, the measuring equipment of the new monitoring system and the individual “budges” themselves were still stored in severely contaminated rooms of auxiliary reactor equipment building of Unit 4. A visit to the building was a risky adventure, but the alternative (leaving personnel of the Chernobyl NPP without individual dose load monitoring) was even worse. Nikolay Istomin and Leonid Vorobyov from the Occupational Safety Dept. realised the situation and they did not wait for an order from the “upper levels”. Operating by their own initiative, they made several visits to room # 530 within one day and manually delivered almost 200 kg of KDT-05 budges and associated maintenance equipment. Unfortunately, on the next day, a helicopter missed its target and dropped its load of bags with clay and lead on the roof of the compartment. The impact completely destroyed the roof plates that collapsed and buried the remaining equipment under radioactive debris.

Rescued budges and instruments were transported to “Skazochniy” camp, washed from radioactive contaminants and the Dose Monitoring Laboratory started to operate 24/7 in the camp’s joinery shop. The laboratory was not fully equipped but it fulfilled its functions. Some additional equipment was provided by Professor Dmitriy Pavlovich Asanov from the Institute of Biophysics (Moscow). He himself and his colleagues Arkadiy Shats, Tamara Gimadova and others relentlessly and unsparingly assisted the NPP personnel. We are very grateful to them, not all the people who were seconded to the Chernobyl NPP zone deserve such a warn praise…

Personnel of other organisations also underwent individual dose control. In parallel with the NPP dose monitoring laboratory, by joint efforts of several governmental bodies, a dose control centre was established in Chernobyl to serve military personnel and specialists who were seconded from different places to participate in mitigation of the accident consequences. The problem of shortage of individual budges and equipment for the Centre was resolved by direct supplies from the manufacturing plant. In such a way, the full system of individual dose monitoring was established, covering the NPP personnel and external participants, notwithstanding the loss of the equipment storage on site due to the roof's collapse.

It is necessary to note that sometimes helicopters failed to drop their load (overall 5000 tons of sand, lead, clay, etc.) onto the destroyed reactor and missed. I myself witnessed such a miss on May 1, 1986 (a holiday) when we, with Igor Kazachkov (the chief Unit 3 shift manager) worked in the Unit 3 control room. A next helicopter load landed several tens of metres outside the reactor building onto the unit transformer and caused a failure of the reactor cooling equipment. We worked calmly in the Unit 3 control room, in silence, when lights suddenly went off, loud alarm signals sounded and instrument panels started blinking. It was surprising, to say the least. Igor immediately run to the security system panels, while I run to the reactor controls. The reactor was in order, its power output did not grow and all control rods were fully inserted into the reactor core. Igor Kazachkov shouted me that control and protection system pumps switched off, as well as the master technical grade water pump and circulation pumps. The emergency back-up reactor power supply system failed to switch on completely - only two diesel-generators started while Igor had to launch the third one manually. On that day Igor exceeded all emergency response standards and prevented a potential accident. Due to high radiation levels, the shifts were reduced to the maximal possible extent, as a results, no operators were available that day. But due to his detailed knowledge of technological systems, equipment locations and practical experience of dealing with the equipment, Igor Kazachkov was able to meet that sudden challenge alone.

It would be truth to say, that no load at all was delivered to the reactor shaft. This does not mean that helicopter crews worked poorly. Quite the contrary. They dropped their loads in absolutely intolerable conditions, in clouds of fumes and steam, under exposure to hundreds and thousands roentgens of radiation. The bulk of their loads landed within the destroyed reactor room, covering the nuclear fuel blown from the reactor. Only a small part of the materials landed on the turbine room roof and in other places.

The below photos show the metal-concrete upper assembly of Unit 4 reactor (construction "E"), that covers the empty shaft of the reactor and prevents entry of dropped bags to the shaft. The assembly is surrounded by shapeless heaps of materials that were dropped from the air. These materials cover the whole demolition area, except the reactor “lid”. Being somewhat previous, I have to note that the reactor itself did not contain any nuclear fuel after the explosion. Some part of the fuel evaporated in the course of its catastrophic runaway on prompt neutrons, some part was dispersed into dust and small fragments. Tens of fuel assemblies, with technological channel pipes and graphite blocks beaded, were blown to the reactor room, while their smaller fragments landed on roofs of nearby buildings or at the NPP site.

Photo of construction "E" with pipes cut off. It is not covered.

A close up view of construction "E". The cone-like objects are media monitoring sensors.

The aerial photo of the reactor room after its filling by materials, dropped from helicopters. In the central part of the photo, the upper "rim" of construction "E" is visible. The rest of it is embedded into the concrete shaft of the reactor with some inclination.

So, what did the helicopter crews work for? According to recommendations of scientists, nuclear fuel should be covered by different materials to reduce emissions of radioactive substances to the air and to prevent a self-sustaining chain fission reaction of uranium nuclei. These materials might be delivered to the reactor room only by helicopters. Whether these operations succeeded to achieve the expected results? Experts' assessments of efficiency of the covering operations are radically different. More details are provided in the next chapter.

Everyday life and health care

On the first day - April 26 - we hardly ever thought about eating. But starting from April 27, meals were provided to the Chernobyl NPP personnel on their workplaces. I do not know how the delivery of food and water packs to the NPP site was organised, but the supply was fairly sufficient. Meals in the summer camp gradually became simply great, food products were fresh and diverse, cooks from the whole Soviet Union worked in our canteen.

We slept on beds and folding beds. We were supplied all the necessary items and nobody neglected personal hygiene. Corres-ondence, newspapers and letters were delivered to the camp. In camp buildings and large tents, accident mitigation HQ, the Occupational Safety Dept., the Technical Planning and Performance Control Dept. (TP Dept.), medical facilities and accounting offices operated. All of us were seriously concerned about our families, so the relevant information centre was organised very timely. Gradually, all of us managed to locate our relatives and ascertain how they were accommodated in their new places of residence. However, our future prospects looked obscure. So far, we had no idea, where and when we could meet our families. But we did not feel ourselves forgotten and neglected, we received numerous cable messages of support from different places. Many people wanted to come here as volunteers to participate in the accident mitigation works.

Besides that, we were not forgotten by investigators, who rather closely worked with almost all of us. I felt that they considered me (similarly to many other specialists of the Chernobyl NPP) as a potential culprit of the accident. It was my Moscow mission for the whole week before the accident that cleared me of charges and prosecution. But I felt myself secure a little bit too early - on 15.05.86, Mikhail Gorbachev, the Secretary General of the CPSU Central Committee, called the Chernobyl NPP personnel guilty in the accident, without waiting for completion of investigation in the framework of the officially initiated criminal case. These words meant that I am also guilty in the reactor explosion.

Aleksandr Davidovich Gellerman, the Chief of the TP Dept. was less lucky. He also was on a mission that week and returned to Pripyat in the morning of April 26, i.e. after the Unit 4 explosion. Investigators started to blame him in authorising the Program of Unit 4 Test, that was followed at the fatal night of the accident. Later, they found that the Program was not signed by Aleksandr Gellerman, it was signed by his deputy Grigoriy Puntus (he also was a well experienced, knowledgeable and respected specialist of the Chernobyl NPP). Then, investigation bodies started to press the both of them. In the court process, Aleksandr Gellerman defended his deputy, he proved that Grigoriy is not a physicist and cannot assess the test parameters that were outside the due instruction manuals. Besides that, he was the last person who signed the Program, after deputies of the Chief Engineer in charge of research and operations (i.e. he signed the Program that had been already agreed by all chief specialists of the NPP and approved by the Chief Engineer, as dates under relevant signatures clearly demonstrate). Arguments of Aleksandr Gellerman were accounted for, and Grigoriy Puntus was left alone. However, as “the contract” for a culprit from the TP Dept. was not cancelled, the Gellerman was punished. He was dismissed from his position and expelled from the Communist Party with a grotesquely worded charge - “for self-abstaining from signature of the Program of Unit 4 Test”. After two years of perfect work and endless efforts to protect his professional reputation, he had managed to prove his innocence and restored his status. The struggle had its price - Aleksandr Gellerman suffered three heart attacks (including one at his workplace) and premature death of his beloved wife from cancer (Olga Dmitrievna Oleynikova, a colleague of mine, an engineer of the Nuclear Safety Dept. of the Chernobyl NPP).

The health care situation was even worse. Almost all of us felt ill. Daily trips to the workplace and back along the route from “Skazochniy” summer camp to the NPP site added 0.01 Sv/day to everyone (the figure corresponds to almost three months exposure of the Chernobyl NPP personnel before the accident). Fortunately, not everyone had to make these trips every day. Nevertheless, practically all of us suffered weakness, somnolence, apathy, memory impairments, bleeding gums and elevated body temperature - such symptoms did not surprise anyone. Medical teams were permanently present in the camp, replacing one another - they collected our blood samples, measured radioactive loads of thyroid gland ... and departed. On May 23, after another visit of external doctors who collected blood samples of the NPP personnel, I asked them on blood count changes of myself and Vladimir Babichev (the chief shift manager of Unit 4, who was also present at the sampling procedure). They told us that blood tests revealed decreasing levels of leucocytes and reticulocytes. My leucocyte count reached 1900 units, while in the case of Vladimir Babichev it reached 1300. Thrombocytes were absent altogether. I asked the doctors what they plan to do with us (they were from the Leningrad Naval Medical Academy), and they answered that they were not authorised to decide on our fate. They only could notify our superiors on the blood test results. After the conversation we returned to our duties. Vladimir Babichev transferred his service duties to his colleague Valeriy Belyaev and departed to Teterev township, where some other personnel stayed. I decided to visit the top managers of the Chernobyl NPP that evening to discuss our health situation. As I found, the doctors had already informed them on our health problems, so a decision was made to transfer us for medical treatment. Using that occasion, our trade unionists loaded me with caviar and other scarcely available products for the NPP personnel members with severe radiation over-exposure who were hospitalised for treatment in Kiev Clinical Hospital # 25. On the next day, with the same group of doctors, we went to Teterev initially to catch Vladimir Babichev and then went to Kiev. In Kiev, we departed. The doctors delivered Vladimir Babichev to Kievskaya Oblast Hospital (they were seconded to the clinic) and left him there for further treatment. I went to Clinical Hospital # 25, where I was expected to undergo treatment. In the Infection Section of the Hospital, a Radiation Pathology Section was established for treatment of the NPP personnel who were not delivered to Moscow Clinic # 6 in the initial days after the accident. The clinic's patients included Sergey Kamyshniy - the chief shift manager of the Reactor Section, Vyacheslav Prudayev - the chief shift manager of the Chemical Section, Yuriy Badayev - on-duty electrician of the unit's "Skala" computer control system. We talked and they described their life in the clinic. They were seriously concerned about uncertainty associated with their radiation over-exposure. They understood that they could be hardly expected to continue working at the NPP due to their radiation exposure, but they had no idea of their future prospects.

The clinic depressed me by its flaccid and somehow sickly atmosphere, that was in a radical contrast to dynamic life in the Chernobyl zone. The Chernobyl zone was hazardous, there we also faced some uncertainty, but is was more associated with unsettled family matters that with future professional prospects. A positive aspect was associated with the fact that we were engaged into important activities and were surrounded by our colleagues. A hospitalisation meant that I could hardly expect to return to our collective. So, having communicated with the friends there I decided to refuse hospitalisation. On the same day, on May 24, I returned to the Chernobyl zone.

Let us return to the fate of Vladimir Babichev. He was treated with daily thrombocyte injections and transfusions, bone marrow tests were made. The team of military doctors (headed by Dr. Fokin) did not fear adverse consequences for themselves and diagnosed Vladimir Babichev to suffer the second grade radiation sickness without agreeing the case with Prof. Angelina Guskova from Moscow Clinic # 6 (under the Institute of Biophysics of the USSR Public Health Ministry). It was a brave, almost heroic act of the doctors, as the final number of patients with acute radiation sickness had been already publicly announced (137 cases) and the USSR Public Health Ministry - and Prof. Angelina Guskova personally - strictly controlled the situation to keep the number constant. If new cases of radiation sickness were diagnosed, the Ministry of Public Health registered them as “vegetative-vascular” disorders.

Two weeks later (on June 10), Vladimir Babichev was transferred to Clinical Hospital # 25 with a more liberal routine than in the oblast-level one. Our patients were not kept in insulated boxes and were able to communicate with each other. Babichev was offered the option of bone marrow transplantation. But he refused to expose his relatives (potential bone marrow donors) to associated heath risks. It is necessary to note that in 1986, in Moscow Clinical Hospital # 6 (Prof. Guskova), 11 from 13 patients with acute radiation sickness died after bone marrow transplantation surgery, while in Kiev where 11 patients were treated by Prof. Kindzelskiy by bone marrow transplantation, all the patients survived. The difference in surgery outcomes cannot be attributed to different radiation exposure levels only, that did differ. Personnel members of the Chernobyl NPP are still very grateful to Prof. Leonid Petrovich Kindzelskiy who treated them with application of his own methodology.

Angelina Guskova and her subordinate doctors from Moscow Clinic # 6 regularly visited Kiev Clinic # 25. They collected there blood samples of Chernobyl workers to estimate their accumulated radiation exposure doses by analysis of chromosome aberrations and transferred the samples to Moscow. The radiation doses of our workers were measured but no information on the results was ever sent to Kiev, notwithstanding repeated requests of the Clinic doctors and patients. Babichev personally requested Guskova on the matter three times but she did not told him the radiation exposure data measured in Moscow. Realising that the Chernobyl substantially politicised the medical sphere he adequately assessed his own capacity and decided to combat the radiation sickness relying on himself only, with use of natural aids. He left Kiev and settled in a rural area, where he worked at the land and changed his life radically. For almost 25 years he continues to manage his subsistence agriculture with skill, as a result, he is still alive. A great man!

My voyage to Kiev and a visit to the hospital did not make me feel better, I still felt fairly bad. It was necessary to do something with the situation, to ascertain causes of the health problems at least. I got information that in Teterev township (nearby the Chernobyl zone), a human radiation spectrometer was installed for examination of the personnel. The spectrometer was used to estimate levels of body contamination by radioactive isotopes. Before that measurement, people were showered to clean surface skin-deposited radionuclides that might distort measurement results. On May 26, two days after my visit to Kiev, I was in Teterev for business and also underwent the examination on the spectrometer. The results are shown in the Table below, measured in Curies per 1 kg (a substance's radioactivity reaches 1 Curie if 3.7×10^{10} radioactive decays happen in it every second):

The thyroid gland (Ci/kg)				
Elements	Isotopes	Activity	MAL	Overcontamination in excess of MAL
Iodine	J^{131}	$9{,}26 \times 10^{-7}$	10^{-12}	in 926,000 times
Ruthenium	Ru^{108}	$6{,}04 \times 10^{-7}$	10^{-12}	in 604,000 times
Zirconium	Zr^{95}	$4{,}26 \times 10^{-7}$	10^{-12}	in 426,000 times
Niobium	Nb^{95}	$3{,}76 \times 10^{-7}$	10^{-11}	in 37,600 times
Internal organs (Ci/kg)				
	Isotopes	Activity	MAL	Overcontamination in excess of MAL
Cerium	Ce^{141}	$2{,}33 \times 10^{-7}$	10^{-11}	in 23,300 times
Iodine	J^{131}	$6{,}92 \times 10^{-7}$	10^{-12}	in 692,000 times
Ruthenium	Ru^{108}	$7{,}59 \times 10^{-7}$	10^{-11}	in 75,900 times
Caesium	Cs^{137}	$3{,}29 \times 10^{-7}$	10^{-12}	in 329,000 times
Zirconium	Zr^{95}	$2{,}86 \times 10^{-7}$	10^{-12}	in 286,000 times

MAL = maximal admissible level of the parameter under control.

My body accumulated radioactive products of fission of uranium nuclei (iodine-131, caesium-137, ruthenium-103 and cerium-141), as well as construction materials of nuclear fuel assemblies - zirconium-95 and niobium-95.

Were these loads high or low? They were high, extremely high. The cumulative activity levels of all the isotopes registered (even without accounting for the thyroid gland) suggested that 52,000 radioactive decays happened every second in every kilogram of my body (while the acceptable level was set as 0.04 decay/second). The tolerable standard was exceeded in more than million times. In the thyroid gland, activity of iodine-131 exceeded the MAL almost in 2 million times. Naturally, I was not the only person who was so heavily "impregnated" by radioactive contaminants, there were much more radioactive people among us.

I started to think what should I do? I did not want hospitalisation strongly and to improve my health I decided to come to my native Urals region, to my mother's. I was sure that she will be the best person to assist me in health improvement, so I urgently arranged a two weeks unpaid leave.

It was not an easy task to buy plane or railway tickets from Kiev at that time. In May 1986, Kiev residents leaved the city in large numbers, and I managed to buy tickets to the Urals and back only using my documents of a participant of works at the Chernobyl NPP. On the same day, I met in Kiev my colleagues from Kiev Institute of Nuclear Research of Ukr. Acad. Sci. We met in the flat of Doctor of Sciences Vladimir Sergeevich Karasev, Vladimir Khalimonchuk and Vitaliy Kovyrshin were also present. We mainly focused on causes of explosion of the Chernobyl reactor, but medical consequences were also discussed. When I showed them the results of my spectroscopic examination, the meeting participants started to make their bets, trying to assess the expected life span of such a walking collection of radionuclides, I transformed into after the accident. Kiev physicists assessed the length of my remaining life as five to seven years, but I told them that it was too early to bury me, as I still had some chances to fight for my life. Eventually, I was proven to be right. Unfortunately, not all of the participants of the dispute are still alive, we lost Vladimir Karasev, who worked fruitfully and intensively in the dangerous Chernobyl zone.

I spent only a week in the house of my mother, in the distant city of Solikamsk. My mother, a former Army doctor fed me by fresh vegetables, greenery and cheese plus multivitamins, insisting that I did not need any additional drugs that time. It was an unusual week, I could even call it a super-clean week. Every morning I regularly attended a standard Russian bath-house. In the bath I silently sat in a steam chamber and sweated, drinking water and kvass slowly. I imagined crystal clear water that washed out radionuclides from every cell of my body, removing them through sweat ducts for eventual washing by shower. My well trained heart of a sportsman endured the long-term heat load without serious adverse consequences, while my mother's salads and multivitamins replenished micro-elements I lost with sweat. Returning after the bath I immediately went to bed and slept for 12 hours with a deep dreamless sleep.

On June 7, on the last day of my stay in Solikamsk I felt myself rather well, much better than before my arrival there. Thanks to my mother, her love, prayers and the bath I recovered. I returned to the Chernobyl NPP full of energy and revitalised and was able to work efficiently almost by the end of the year. In December, I again felt ill and in January 1987, doctors referred me to Moscow Clinic # 6. But it is worth to note that a spectroscopic examination in Clinic # 6 revealed a substantial decrease of my radioactive body load comparatively to results of my examination in Teterev township in late May 1986:

Isotopes	Overcontamination in excess of MAL
$Cs^{134} = 4.0 \times 10^{-11}$	in 40 times
$Cs^{137} = 1.0 \times 10^{-10}$	in 100 times
$Zr^{95} = 1.0 \times 10^{-11}$	in 10 times
$Nb^{95} = 1.0 \times 10^{-11}$	in 10 times

The overall radiation intensity decreased in almost 14 thousand times (to 1.6×10^{-10} Ci/kg, or only 6 radioactive decays per second per 1 kg of body weight). It is clear, that in 7 months short-lived isotopes (iodine and ruthenium) decayed completely, but I attribute the rest of reduction of my personal body load to the period of my body “cleaning” in the Urals region.

Let us return to the Chernobyl NPP. The works at the NPP site, launched by the Governmental Commission for Mitigation of Consequences of the Chernobyl Accident required involvement of growing numbers of specialists. The Chernobyl NPP Administration started to call in the personnel who were allowed to evacuate from Pripyat on April 26 - 27. Workloads increased every day, in line with large-scale works at the NPP site and in the Chernobyl zone - the works were conducted with involvement of the whole country. Our tasks were associated with preparing three reactor units to reloading and subsequent launch. Some systems were modernised accounting for experience of the April 26 accident (particularly reactor control and protection systems). That did not meant that the NPP did not face any urgent problems. The background radiation level at the NPP site still was very high, radiation releases from the damaged reactor unit continued. The Governmental Commission was still obsessed by serious - albeit fantastic - concerns associated with a potential explosion under the Unit 4 reactor in the case of fall of the fuel melt into water of suppression pond, located under the reactor. Thousands soldiers and officers of the Chemical Corps were involved into works of unprecedented scale and complexity, trying to decontaminate the NPP site and surrounding areas from radioactive substances. The country strained under the back-breaking load, caused by the runaway "peaceful atom".

The Task Force of the Political Bureau of the CPSU Central Committee in charge of liquidation of consequences of the Chernobyl NPP accident started to hold regular meetings. Secret minutes # 1 of the meeting of April 29, 1986 reveal that the following agenda items were discussed:

1. The situation after the accident at Unit 4 of the Chernobyl NPP.
2. Radiation situation at the Chernobyl NPP site, in the NPP township and in adjacent areas.
3. Arrangements for provision of health care services in areas under radioactive contamination.
4. Participation of the Civil Defence units in the accident mitigation works.
5. Evacuation of residents of the city of Pripyat.
6. The case of disembarkation of a group of train passengers in the restricted area.
7. Deployment of the Chemical Corps Brigade.
8. On allocation of 10 thousand Army food rations for distribution among the evacuees.
9. Tentative causes of the Chernobyl NPP accident.
10. Governmental information releases.

The executive vertical to manage issues associated with the Chernobyl accident had been completed, all Chernobyl-related issues were considered urgent and addressed without delay, albeit with a varying success and not always as expected.

Science takes its toll

"On May 6, 1986, at the press-conference of B.E. Scherbina, A.M. Petrosyants, the Chairman of the USSR State Committee for Atomic Energy said appalling words, trying to exonerate the Chernobyl disaster: "Science takes its toll". He thought he said a wise thing, but it sounded stupid and cynical. People are dying..."

G. Medvedev, "The Chernobyl Notebook".

Problems multiply

In order to illustrate the chain of disastrous events I will provide a brief description of causes of the explosion of Chernobyl Unit 4 reactor (see a more detailed account in Part 4 of my first book "Chernobyl. The Revenge of the Peaceful Atom" and in Konstantin Checherov's "Experimental Study of the Destroyed Reactor").

So, at the beginning of April 26, 1986 (01:23:37) the test at Unit 4 was successfully completed, but the subsequent events were absolutely unexpected - the reactor power output started to rise. At 01:23:39 when automatic power control rods were inserted completely, Leonid Toptunov, the chief reactor control engineer, pressed SDS-5 button (the standard reactor shutdown procedure). All control and safety rods started to descend (except 24 shorter adsorber rods, that were inserted into the reactor from bottom-up), that resulted in decrease of power output within the first second. But, starting from second 2, the reactor power output again started to rise. The effect was caused by the design fault of the reactor control and safety system (the terminal effect of displacers of control and safety rods) (see Karpan N.V., "The Revenge of the Peaceful Atom", 2006, Dnepropetrovsk, p. 334). Due to growing power output at the background of decreasing water flow through "running-down" MCPs (main circulation pumps), water with a temperature just a little below boiling point at the entry to technological channels had completely evaporated and filled the channels by steam. The steam caused additional increase of the power output due to the void reactivity coefficient. Intensive steam generation in the active core and subsequent rise of reactivity and power output resulted in growing pressure in the multipass forced circulation circuit up to reaction of return valves at distributing group headers that supply water to the reactor. The active core started to lose water. Then the process developed catastrophically - see a detailed account of the events in the paper of Adamov E.O., Cherkashov Yu.M. et al (Atomic Energy, v. 75, # 5, November 1993) and in K.P. Checherov's "Experimental Study of the Destroyed Reactor".

Estimates of Kurchatov Institute of Atomic Energy demonstrated that "operating two of four MCPs of every part from the turbine generator running down, with gradually decreasing flow may cause development of the catastrophic process even without additional positive reactivity of displacers of the control and safety rods". The terminal effect caused by the launch of SDS-5 safety system transformed an abnormal process of relatively smooth growth of the reactor power output into a nuclear explosion. In that case, "the terminal effect" was higher than usual due to a low reactivity margin (only about 10 rods were inserted at the moment when SDS-5 button was pressed) at very low underheating of the cooling water entering the reactor (Karpan N.V., "The Revenge of the Peaceful Atom", 2006, Dnepropetrovsk, p. 349). The reactor with positive reactivity got critical on prompt neutrons (Karpan N.V., "The Revenge of the Peaceful Atom", 2006, Dnepropetrovsk, p. 365), that naturally resulted in a nuclear explosion with a yield of 30 tons TNT equivalent. The explosion yield estimate was taken from “Expert Conclusions” of May 16, 1986 - the document, similarly to some other documents of the Sectoral State Archive of the Security Service of Ukraine, was declassified on 20th anniversary of the Chernobyl disaster.

Uncontrolled growth of the reactor’s power output is similar to a nuclear explosion. The only difference between the Chernobyl reactor runaway on prompt neutrons and the explosion of the first uranium bomb is associated with the fact that in the case of the bomb, the bulk of the fissionable material reacted before the bomb parts were blown out by the explosion. Correspondingly, the energy release was greater comparatively to the explosion of the Chernobyl reactor.

In the case of a nuclear bomb, a higher explosive energy release is ensured by a preceding detonation of “implosive” charges of conventional explosives, that contain a critical mass of a fission material in a compact state for a time necessary to generate maximal possible number of fission reactions and release the maximal energy. In the case of Chernobyl, the time of the chain fission reaction in the nuclear fuel was shorter comparatively to a nuclear bomb, as the energy release dispersed nuclear fuel and the moderator when the strength of reactor constructions was exceeded. About 10% of uranium from the overall fuel load of the reactor underwent fission within the time of the explosive process (by the moment of explosion the reactor contained about 50 critical masses of uranium - see Karpan N.V., “The Revenge of the Peaceful Atom”, 2006, Dnepropetrovsk, pp. 275, 276).

Uncontrolled reactor runaway, that ended by the explosion, partly evaporated and scattered nuclear fuel and graphite, and the explosive evaporation of water destroyed the critical system. The regular spatial distribution of nuclear fuel and moderators (graphite and water), favourable for a self-sustaining chain reaction, was distorted - as a result, the chain fission reaction died out at the early stage. Therefore, by the moment of destruciton of the critical system, only a some part of nuclear fuel reacted (the one generating a sufficient energy to destroy the critical system). Due to a relatively small yield of the explosion (comparatively to a nuclear bomb) some specialists still call the Chernobyl reactor explosion a thermal one notwithstanding its nuclear nature.

In a simplified form, the accident process may be subdivided into three distinct stages:

1. The nuclear explosion in the local area of the reactor, that generated enough energy to evaporate and disperse a some part of the active core and destroy technological channel pipes and control rods made of boron-enriched steel;

2. The steam explosion caused by contact of water from fractured channel pipes with graphite heated to 525 °C. The steam generation caused growing pressure in the reactor case, cut off construction “E” (the upper assembly of the reactor shaft) and eruption of all residual active core materials (fuel, graphite, channel pipes and control rods) to the reactor room (similarly to a pressure cooker eruption). At that stage, the intensive steam-zirconium reaction of channel pipes started generating the temperature up to 4650 °C (close to the Sun surface temperature).
3. The air-fuel detonation over the reactor room floor - the explosion was caused by residues of the active core released by the steam explosion and the gas-air mixture formed. The study of spatial distribution of damaged construction elements suggest that the epicentre of the explosion that destroyed the reactor room building was located at the height of about 30 - 40 m over the floor of the reactor room (K.P. Checherov “Experimental Study of the Destroyed Reactor”).

The nuclear fuel underwent the following transformations: the energy pulse of the nuclear chain reaction heated the fuel in the epicentre of the explosion up to forty thousand degrees Centigrade (presentation of A.N. Kiselev and K.P. Checherov - “The Process of Destruction of Chernobyl NPP Unit 4 Reactor” - at the Ministry of Emergency Response Conference on “Overcoming Consequences of the Chernobyl Accidents. Conclusions and Prospects”, May 2001). In the course of these events, a some part of nuclear fuel (at least 10% of the fuel load), as well as channel pipes, control rods and graphite simply evaporated (dimensions of the epicentre may be roughly estimated by the size of the gap in the bottom part of the reactor shaft). Fuel assemblies adjacent to the epicentre of the nuclear explosion (about 30% of the fuel load) were dispersed into small particles in the range from 100 to 1 µm. Fuel and graphite located farther from the epicentre (about 30% of the load) were dispersed into particles sized from few millimetres to few centimetres. The assumption is confirmed by multiple pieces (at least a hundred thousand) of radioactive residue of fuel assemblies, both empty and ripped open as sheets of paper (about 4 x 5 cm) that were collected at the Chernobyl NPP site in the course of decontamination works of Summer 1986 (Yuliy Andreev, Chernobyl and Corporations, # 472, April 23, 2006).

The rest of the fuel load (also about 30% of the load) was blown out from the reactor as large fragments, including large pieces of fuel assemblies, and fuel assemblies inside channel pipes (inserted into graphite blocks of different heights).

Some fuel was thrown down into empty compartments under the reactor shaft though the gap formed in the bottom part of the reactor shaft under the epicentre of the nuclear explosion. Available video-footage shows that the orange-red glow was visible for a little bit over 2 days after the explosion under construction "E", that covered the reactor shaft obliquely. The glow was generated by red-hot lava-like melt of fuel and different construction materials of the reactor. These fuel-containing masses rather quickly spread out under their own weight as the destruction and technological corridors allowed and then solidified, when their temperature gradually decreased. Later on, researchers subdivided the "spill" into three components - the large vertical spill (from the reactor shaft to the under-reactor spaces), the small vertical spill and the horizontal one. Fuel (uranium dioxide) contents in the solidified spills varies from 5 to 10% (A.A. Klychnikov et al, "Shelter" Facility 1986 - 2006, Chernobyl, 2006, p. 26). The fuel is present as fine particles embedded into a silicate matrix. The overall amount of uranium in these masses is assessed as merely 30 tons (NUCLEAR ENGINEERING INTERNATIONAL , Vol. 44 No 534 January 1999 p. 27). Accounting for the fact that the explosion had blown up about the same amount of dispersed fuel, the overall amount of the fine fraction of dispersed fuel could reach at least 30% of the initial reactor fuel load. In addition to the lava-like melt under the reactor (bottom construction "OR", and the floor of the under-reactor compartment) K.P. Checherov found fuel assemblies with intact fuel elements, that confirm a short duration of destructive processes of April 26.

As video- and photo materials confirmed later, a fragment of fuel load generated a glow at the floor of the reactor room, at the distance of few meters from the protruding rim of construction "E" (the fragment of the active core was blown up from the reactor by the explosion). The glow there was observed for about 64 hours after the explosion (K.P. Checherov, "Unpeaceful Atom of the Chernobyl", "Chelovek" magazine, # 6, 2006 - # 1, 2007).

The issue of the amount of the radioactive release from the reactor is also of some interest. The Soviet Union officially admitted the air emissions of 50 million curies. Later on, the figure was adjusted many times and the final estimate suggests 150 million curies. However, the actual release is even higher. The pre-accident estimates of Kurchatov Institute of Atomic Energy suggest that a standard RBMK reactor that reached a pre-set burnup level and operates at its standard capacity accumulates up to 10 billion curies of radioactive substances (gaseous and solid fission products). By the moment of shutdown of the reactor, every ton of irradiated nuclear fuel contains about 40 million curies of fission radionuclides and more than 0.1 million curies of strontium-90 and caesium-137 ("The Reference Source Book on Generation of Nuclides in Nuclear Reactors", Moscow, Energoatomizdat, 1989, pp. 188 - 191). Therefore, it is not surprising that the reactor's explosion released to the environment not merely 50 million curies but the twenty times higher amount - i.e. at least 1 billion curies (10% of the accumulated content). The release contained more than a half of accumulated radioactive inert gases, caesium, strontium and the bulk of explosion-generated fine particles of the nuclear fuel.

So, the explosion destroyed the regular structure of the active core of the reactor (channel pipes with fuel assemblies separated by 25 cm of graphite brickwork). After the explosion, the new pattern of distribution of fuel, graphite, construction materials and cooling water was not favourable for a self-sustaining chain reaction due to the altered geometry of the fuel-graphite system and "poisoning" of the fuel by neutron-adsorbing fission products (iodine, xenon). However, the latter neutron adsorbers decay rather swiftly (in a few hours), allowing closely located residues of nuclear fuel again participate in the chain fission reaction. My estimates, made in the morning of April 26, suggested that the fuel might depoison sufficiently for a new chain reaction by about 7 p.m. posing a threat of an uncontrolled chain reaction in the residues of the reactor's active core. Urgent measures were needed to prevent the repeated uncontrolled chain reaction. As I already noted in the opening chapters, to this end a sufficient amount of additional neutron adsorbers should be injected into the fuel-containing mass to make the fuel sub-critical even after its complete depoisoning. I demanded the NPP Administration to deliver urgently at least 1 ton of boric acid to the NPP site (boric acid contains boron - a neutron adsorber). However, we had failed to utilise the pause of 17 hours available to us that day for guaranteed shutdown of the reactor due to sluggishness of the Governmental Commission for Mitigation of the Chernobyl NPP Accident and top managers of "Soyuzatomenergo" Industrial Association[6]. The boron we requested in the morning was not loaded to a plane or a helicopter, they loaded it into a truck that arrived on the NPP sine only on April 27, when the anticipated events had already happened (E.I. Ignatenko, "Two Years of Liquidation of Consequences of the Chernobyl Disaster". Moscow,

The view of the northern side of the destroyed reactor unit building. Releases of water vapour and radioactive products are visible.

[6] *The USSR Directorate for NPP Operation*

Energoatomizdat, 1997, p. 56). I consider it as a very serious fault of the Governmental Commission. As a result, the additional neutron adsorber was not added to the fuel mass, that would maintain the destroyed reactor in a sub-critical state after decay of the neutron “poisons”, making the new chain reaction impossible. In the evening of April 26, in areas of accumulation of nuclear fuel blown out from the reactor, the new pulse chain reaction started, causing the fire in the damaged reactor building. The fire increased radioactive releases from the ruined unit in several tens of times, endangered life of Pripyat residents and caused serious concerns in European countries that had already registered the first wave of radioactive releases by that time.

I will never forget that fire. I have never seen a more dreadful and impressive scene (I observed it from the distance of less than 100 m from Unit 4) - the fire was accompanied by loud roar and fountains of light and flames of varying colours. Nobody even attempted to extinguish the fire, all firefighters of Ukraine could not do anything with it.

Residents of Pripyat perceived these spectacular events with a surprising calm. Nobody panicked even a little bit. I should not say that they did not realise the hazards associated, they simply used to trust the authorities, assuming that they will ensure their safety in a due course and timely. But the authorities failed to warn the city residents on the imminent danger and did not conduct a full-scale preventive iodine therapy (to protect thyroid gland from adsorption of radioactive iodine). As a result, people did not protect themselves by closed windows and doors and inhaled radioactive air at the streets, in the open, working at the land nearby their summer houses.

The fire ceased by 5 a.m. of April 27, but due to residual heat generation temperature of the nuclear fuel remained rather high. It was necessary to ascertain how high it actually was. All interested parties wanted to know the temperature in the reactor room debris, to be able to understand the processes inside, at least roughly. They succeeded only on May 1, when researchers managed to measure temperature there directly. To this end, the experimental thermocouple was dropped from a helicopter, allowing to measure temperature with precision of ±10%. The operation was supervised by E.P. Ryazantsev - now he is the Director of Reactor Technologies and Materials of “Kurchatov Institute” Russian R&D Centre. The temperature in the unit debris was found to reach 300 °C. The Governmental Commission was so shocked by such a low temperature (they expected several thousand degrees Centigrade), that its members did not believe the measurements and started to develop absolutely fantastic models of the reactor’s behaviour (K.P. Checherov, “Unpeaceful Atom of the Chernobyl”, “Chelovek” magazine, # 6, 2006 - # 1, 2007). Nevertheless, even that temperature was sufficient to release radionuclides with convective air flows to higher altitudes, up to 3000 m. Then, radioactive contaminants were transported by air currents in different directions.

It was clear for all that the problem of radioactive contamination of the atmosphere would soon become an international problem. Therefore, the Governmental Commission requested scientists to develop urgently some measures for reduction of releases of gaseous radioactive products, fine particles of nuclear fuel and contaminated construction materials to the air. After some deliberations, the scientists proposed to cover the reactor itself and the reactor room by loose materials for establishment of some safety barriers, including application of boron-containing materials as neutron adsorbers (nuclear safety barrier), establishment of a filtering layer of clay and sand (radiation safety) and application of lead to adsorb heat, and dolomite clay to reduce anticipated graphite burning due to generation of carbon dioxide (thermal safety). However, before creating these barriers, it was necessary to ascertain the following things:

1) where is the nuclear fuel located and in what amounts?

2) whether the chain fission reaction still continues or it has already ceased?

3) is a new fire possible (such as fires in the evening of April 26 and at night of April 27)?

The above questions did not have clear and easy answers at that time. I have to admit that no information was available in April - May 1986 to answer question 1 comprehensively and reliably. Photos of the damaged reactor room did not allow to see and identify anything of value. We also had the pre-accident information on the amount of fuel unloaded from the reactor in the process of its operation and stored in the wet INF cooling pond (118 fuel assemblies), located nearby the damaged reactor in the southern part of the reactor room. Besides that, we also knew the reserve of new fuel rods in the in-house fresh fuel storage (144 fuel assemblies at the western wall of the reactor room). But that was all we had. It was necessary to conduct large-scale measurements of fuel releases outside the reactor room and the Chernobyl NPP site. It was necessary to survey closely the adjacent compartments of the reactor shaft. Accounting for high contamination levels there that substantially exceeded 10 Sv/hour, such works required involvement of specialised radiation monitors of the highest possible qualification, who should have the necessary skills and adequate equipment for operation in mortally dangerous conditions. In late April - early May, we did not have such specialists and instruments, that could meet the challenges of the radioactive contamination at the NPP site. As a result, the first question remained unanswered. Nevertheless, on April 27, 1986, the Governmental Commission decided to launch covering the reactor immediately.

The second question (whether the chain fission reaction still continues or it has already ceased?) was answered quickly. Analysis of air samples revealed absence of short-lived gamma active isotopes that are generated in the course of the chain fission reaction. These results unequivocally suggested that the chain reaction had ceased.

The answer to question # 2 provided an indirect answer to the third question as well (is a new fire possible such as the fire in the evening of April 26?). The scientists argued that as air samples did not reveal signs of the chain reaction, that meant that conditions for its emergence ceased to exist any more. So, the self-sustaining chain reaction in the Unit 4 debris could not emerge if no steps would be made to increase the neutron multiplication factor. Addition of boron, lead, sand and dolomite into the reactor debris would make the self-sustaining chain reaction there finally impossible.

The threat of the self-sustaining chain reaction was eliminated, but it was too early to calm down. Academicians E.P. Velikhov and V.A. Legasov persuaded the Governmental Commission that another cataclysm is possible - a steam explosion of disastrous force, caused by the fuel melt burning through the support plate of the reactor and entering the compartments of pressure suppression pools beneath the reactor filled by water. According to the academicians, such an explosion could destroy the Chernobyl NPP completely and spread radioactive materials throughout Europe. The explosion might be prevented only by removal of water from the suppression ponds beneath the reactor (if the water was still there and was not evaporated by the fire after depoisoning of the nuclear fuel in the evening of April 26 - night of April 27).

In order to check presence of water in the suppression pond, the NPP personnel opened a valve at the pulse tube from the suppression pond. When the valve was opened, no water was found inside, just the opposite, the pipe started to suck air towards the pond. It was not enough to convince the scientists and they continued to demand more serious evidence that the suppression ponds do not contain water. The Governmental Commission ordered the Chernobyl NPP Administration to find a place in the suppression pond wall (180 cm of strong reinforced concrete) where the military might place explosive charges to made a hole to pump water out. Nobody had even a slightest idea whether such an explosion might endanger the building of the damaged reactor. In the night to May 4, the order reached the deputy Chief Engineer of the Chernobyl NPP Aleksandr Smyshlyaev, who immediately forwarded it to Igor Kazachkov, the chief shift manager of Unit 3. Kazachkov answered that the option of penetrating almost 2 m thick wall in conditions of high radiation was not the best way to dewater the polls and he would look for a less destructive one. After review of technological drawings, Kazachkov decided to explore the option of opening valves at the suppression ponds' discharge pipes. He took a torch, DP-5 radiation meter and went to the valves' compartment accompanied by operator M. Kastrygin. The compartment was filled by radioactive water to the level of about 1.5 m. The water inside was contaminated to EDR over 200 R/hour (above the instrument's scale), but the valves themselves were intact as the explosion did not reach the compartment and did not damage anything there. After his return, Kazachkov informed Smyshlyaev that the water discharge valves could not be opened without removal of water from the pipeline corridor. However, at all events, it would be much easier to pump out the "dirty" water than to blast the suppression pond wall. In addition, the radiation level in partly flooded basement compartments of the NPP would sharply decrease after the water discharge.

The proposal of Igor Ivanovich Kazachkov was accepted. In the morning of May 5, the Governmental Commission dispatched a team of the military and firefighters to the Chernobyl NPP under command of Captain Petr Pavlovich Zborovskiy (Civil Defence Corps.) The NPP personnel already prepared to removal of water from basement compartments for a long time. In early May, at the initial stage of the operation, the team was assisted by V.K. Bronnikov who was the acting Chief Engineer of the NPP at that time.

Locations of two fire engine vehicle pumps PNS-110 in the transportation corridor and the route for discharge of water to the sludge pond (more that 1 km long) were marked in advance. Members of the NPP shift personnel showed the military these points in a few days before the water pumping operation. Besides that, when the operation was launched, the NPP personnel members led the firefighters (V.L. Bovt, I.P. Voitsekhovskiy and M.A. Dyachenko) through corridor 01/1 to stairway compartment 05/1 of ARE unit, located beneath the intact Unit 3. The water intake point was located there. The corridor was a relatively safe place comparatively to Unit 4. Besides that, the corridor was connected to the counterpart corridor under Unit 4, allowing to pump water out from lower compartments of the both reactor units simultaneously and to open access to the discharge valves of suppression ponds of Unit 4.

The military and firefighters very quickly assembled the flexible water line and the fire engines started to pump the water out. Then, the operations participants departed to a safer place and attended the scene periodically to check the vehicles in work and fuel them. The shift NPP personnel also monitored the water pumping process. When water level nearby the suppression pond discharge valves under Unit 4 decreased to about 50 cm, V. Gristchenko, the RS chief manager ordered senior engineers A. Ananenko and V. Bespalov to enter the compartment. They were accompanied by B. Baranov, the NPP shift chief manager. Wearing rubber wet suits, with torches and wrenches in hands, they reached the valves and checked their serial numbers. Boris Baranov stood by to secure them, while Aleksey Ananenko and Valeriy Bespalov started to open the discharge pipelines manually. The operation took about 15 minutes. They heard noise of water flowing from the lower level of the suppression pond - the noise confirmed that they had got the necessary effect. When they returned after completion of their task, they checked their dose-meters (they were issued military optical DPK-50 dose-meters - so called “pencils”) - they got 10 maximal annual doses each.

Actually, it was a typical story of that time. They “burned” the personnel all the time. The Governmental Commission relentlessly “invented” new tasks while the NPP shift personnel puzzled their brains trying to fulfil them. In particular, after the discharge of water from the suppression pond, Academician A.P. Aleksandrov proposed to make a hole in the pond’s wall for further filling the pond by magnetite cement. That time, NPP workers also were the first persons who went to the pond - G. Reikhman and N. Shteinberg. In early morning of May 8 (by the time of the night shift’s end) they identified a point in the suppression pond wall for installation of concrete-pumping pipes. The entry hole itself was perforated in the thick concrete wall of the pond by construction workers of the Chernobyl NPP Construction Directorate, who cut the wall by plasma torches for more that seven days without breaks (the works had been completed by May 15).

It is necessary to note that the Governmental Commission tried to award adequately the people who participated in such lethally dangerous works. The deputy Chief of “Soyuzatomenergo” Evgeniy Ignatenko (E. Ignatenko. The Liquidator’s Notes. Moscow, 1991, p. 54) described the situation as follows: “… when we got an opportunity to reach the compartment where the valve was installed, the NPP workers in rubber wet suits entered the compartment, half-flooded by highly radioactive water with contamination up to 10 curies/litre and opened the discharge valve (they opened two valves - N.K.) … The information was immediately reported by I.S. Silaev (the deputy Chairman of the USSR Council of Ministers, who was the acting Chairman of the Governmental Commission on Chernobyl - N.K.) to the highest level of governance of the country and the republic, and our actions at that stage were approved. The event happened on May 6, and on May 7 Silayev issued the decision of the Governmental Commission on awarding us a honorary mention and monetary bonuses of 800 - 1000 roubles to each… Overall, the group included 8 to 10 persons. The bonuses were awarded to us for saving of Kiev. Some rumours circulated that a few members of the group should be nominated to the title of the Hero of the Soviet Union. Besides me, the group included: E.S. Saakov, V.K. Bronnikov, V.V. Gristchenko (the chief NPP RS manager), V. S. Konviz (the deputy Chief Engineer of "Gidroproekt[7]" Institute), plus some workers of the Chernobyl NPP, who participated in the opening of the half-flooded valve and firefighters who participated in organisation of the water pumping operation…"

Pert Zborovskiy, the commander of the team of military specialists and firefighters, who ensured the technical aspects of the water pumping operation and got dangerously high radiation doses in the process, described the same case a little bit differently and less pathetically ("Zerkalo Nedeli" # 38 (207) September 19 - 25 1998): "By the end of the second day of our work at the NPP site, some civilian arrived and handed me a thousand roubles - the bonus from Silaev. 15 persons were awarded that time. I was the only military serviceman in the list. The money was delivered in an envelope. As a matter of fact, the envelope was addressed to Borovskiy instead of Zborovskiy, but all other personal details were adequate: '... Petr Pavlovich, a Captain, the Civil Defence Corps regiment' … In December, in Moscow, the "Chernobyl" award ceremony was held. At that time, nobody from our regiment was awarded, notwithstanding that we operated in the team from the initial hours after the accident and made a lot of work worth awards… Some time later, in May 1987 I was also awarded by the Red Star Order. I read the extract from the awarding decree: '... for mastering new equipment and armaments".

Operator Mikhail Kastyrin, who surveyed the route to the suppression pond discharge valves with Igor Kazachkov, was treated more justly. He was awarded the Order of the October Revolution.

The authorities did not forget Igor Kazachkov, who proposed the idea of discharge of water from the suppression pond without explosives and who was the first to survey the route to the flooded valves. He got more than 10 maximal radiation doses and a monetary bonus of 200 roubles for his tour beneath the reactor. He got no orders or medals… I has not managed to find the text of the Decision of the Governmental Commission on awarding the specialists who made distinguished efforts in the course of pumping water out from the suppression pond. I am grateful to E.I. Ignatenko who specified names of main participants of the dangerous operation in his book, otherwise the general public would have never know about them.

So, the NPP personnel, the military and firefighters had discharged water from the suppression pond and paid by their health to the

[7] *S.Ya. Zhuk Gidroproekt R&D Institute - the lead designer of powerhouse NPP equipment*

success. However, the scientists did not cool out. As E. Ignatenko recalled, they "had some conservative estimates suggesting possibility of sinking (of the fuel melt - N.K.) to depth up to 3 km." (Two Years of Liquidating Consequences of the Chernobyl Disaster", Moscow, Energoatomizdat, 1997, p. 62). Then, the scientists had convinced the Task Force of the Politbureau of the CPSU Central Committee and the Governmental Commission in the need to start blowing the reactor debris by nitrogen. And again, the Chernobyl NPP workers were among the first who surveyed the demolition zone - the chief shift manager of the Unit A. Kedrov and senior mechanic engineer D. Nebozhchenko. DP-5 dose-meter in hands of Anatoliy Kedrov went off-scale, overshooting the upper margin of 200 R/hour. Nobody knows the dose of radiation they got that time.

The system for cooling the reactor debris by nitrogen was assembled but it was still too early to calm down. The scientists imagined another potentially dangerous situation. They demanded to reinforce the foundation of the damaged reactor by a monolith cooled plate to avoid the situation when "a white-hot crystal of nuclear fuel, burning through under-reactor constructions" might sink, penetrating the Earth to reach our strategic opponents. Miners had to excavate a cavity with dimensions of 30 m x 30 m under the reactor unit. And they did. Overall, 388 persons participated in these works, including 154 Metro construction workers from Moscow and other regions, plus 234 miners from Dondass. (M.S. Odinets. "Chernobyl. The Ordeal Days". Moscow, 1988, p. 112). The radiation level at the point of entry to the cavity from the side of Unit 3 reached 5 roentgens per hour (it was impossible to make the entry point from the side of Unit 4 as radiation intensity there reached more than 500 R/hour). However, even 5 R/h is a large figure - it corresponds to the maximal annual dose of NPP professional personnel in the case of standard NPP operations. God knows how many annual doses these people got … They completed excavating the tunnel to the cavity and the cavity itself in 25 days.

What was the result of heroic efforts of the NPP workers, the military, firefighters and miners? Unfortunately enough, they worked in vain. The actual situation developed as follows: in initial days of the accident, hot fuel-containing masses reached the pressure suppression pond through steam discharge valves and peacefully solidified there without generating any steam explosion. Research studies of the team of K.P. Checherov demonstrated that "the melt really reached water of the accident localisation system and solidified due to water cooling, without exploding anything, without burning through anything, without even fusing the concrete foundation. In the course of surveying compartments of the suppression pond we found that in many of them, at the height of about 1.0 - 1.1 above the floor (a standard level of water in the suppression pond) metal constructions were covered by fuel-containing porous pumice-like materials with density of about 0.14 to 0.18 t/m^3. Due to their low density, these materials floated at the water surface and slowly travelled in the compartments. We found these pumice-like materials in compartments of the suppression pond at distances up to 30 m from steam discharge pipes, through which the fuel-containing melts trickled down. Therefore, it became clear that we should not fear 'the China syndrome' and all the works for installation of the cooled plate under the reactor foundation were merely a reassurance". (K.P. Checherov, "Unpeaceful Atom of the Chernobyl", "Chelovek" magazine, # 6, 2006 - # 1, 2007).

Covering the reactor unit

Overall, about 5000 tons of different materials were dropped onto the debris of the reactor unit in the period from April 27 to May 10:

- 2400 tons of lead (to cool the fuel),
- 40 tons of boron carbide (to prevent initiation of the chain reaction),
- 800 tons of dolomite (to generate carbon dioxide to suppress burning processes),
- 1800 tons of sand and clay (to filter radioactive releases).

The need to apply the covering and its potential implications are still debated. Some argue that the covering reduced radioactive releases from the unit and extinguished burning graphite. Some others claim that graphite did not burn at all, and the covering was just a unnecessary obstacle preventing convective air flows through the destroyed reactor. And really, starting from May 2, monitoring instruments registered growing releases of radioactive substances from the demolition area. The artificial obstacle of the covering materials caused increasing temperatures of the fuel below and enrichment of the emissions by non-volatile radioactive isotopes, particularly by plutonium ("The Other Chernobyl Report (TORCH)". Berlin, Brussels, Kiev, 2006). Overall, the covering of the reactor resulted in longer duration and higher intensity of radioactive releases, in additional area contamination by radioactive substances, in additional radiation exposure of the NPP personnel and the military.

Let us consider some facts to understand these critical arguments. Overall, in the period from April 27 to May 10, helicopters dropped five thousand tons of different covering materials onto Unit 4 debris. According to reports of the scientists who proposed the covering operation, the anticipated results were achieved. However, many people challenge the claim. For example, Grigoriy Nadyarnykh, the Director of the Engineering Centre of Applied Ecology, wrote ("A

Chernobyl-like Accident was Inevitable", "New Time" magazine, 1991, # 29): "After the covering, air access to the reactor debris was limited and its natural cooling mode was interrupted. A "dry boiling" effect was produced, as a result, on May 3 to 5, radioactive releases sharply intensified and the temperature inside the reactor debris increased up to 3000 degrees".

According to the former Minister of Power Industry and Electrification G.A. Shasharin, the idea to use lead was proposed by the deputy Chairman of the State Nuclear Power Supervision Authority, an Associate Member of the USSR Acad. Sci. V.A. Sidorenko - "to reduce radiation intensity"...

The associated decision-making details were described by the former deputy Chief of "Soyuzatomenergo" E.I. Ignatenko (The Liquidator's Notes. Moscow, 1991, p. 34): "I was concerned about one thing only - the boiling point of lead. For some obscure reason I thought that it is around 900 degrees. Therefore, lead would boil and its vapour would escape with radioactive contaminants. I tried to find it in the NPP Chemical Section, but they did not had a reference book in hand. Finally, I called my wife in Moscow - she asked me to call her again in about half-hour and then said that lead boils at 1700 degrees. The figure was acceptable for us".

What has happened with the lead? According to scientists, lead simply disappeared in a some mysterious way. Academician Spartak Belyaev described the situation as follows: "... we did not found lead inside the reactor unit and we do not know where it went or escaped after melting. When the turbine room building was reconstructed, some bags were removed - the ones that were dropped from helicopters through the roof - but no lead-containing bags were found. Lead was not found in the unit compartments beneath the reactor... No lead was found outside the reactor unit" ("Nature" magazine (Rus.) # 11, 1990, Liquidation of Consequences of the Chernobyl Disaster).

I think that the latter statement of the honourable scientist seems questionable. We registered lead at the Chernobyl NPP site as early as in 1986. Unfortunately, at that time we did not have specialists to find lead in the Summer. We were able to do it only in the autumn of 1986, and we immediately identified lead in indoor air and at the NPP site. And its levels were high. The matter is associated with the fact that lead evaporates at only 450 °C. Due to such properties, immediately after the covering, lead started to evaporate and infiltrate human lungs and other internal organs. Thousands people coughed, suffocated and felt ill. Naturally enough, lead was not the only underlying cause - see the Report Note below. Taking into account that the measurements were conducted four months after delivery of lead into the damaged reactor unit and after large-scale decontamination works at the NPP site, in the autumn we registered rather low lead concentrations (comparatively to May levels). But even the autumn concentrations exceeded MACs (maximal acceptable concentrations). We will never ascertain lead levels in air in summer months of 1986 (May - August). But we do know the number of patients who applied for health assistance with complains about strong cough, **about 5000 cases in 80 summer days.** I will not attribute the cases to lead effects only, but it surely affected human heath.

Справка

о предварительных результатах исследования уровней загрязнения производственной среды и приземного слоя атмосферы промплощадки ЧАЭС токсичными химическими компонентами.

В период с 5.09.86г. по 11.09.86г. были проведены санитарно-химические исследования воздуха и смывов на токсичные химические вещества (раздражающего и общетоксического действия) с целью выявления возможного влияния их на организм работающих, участвующих в работах по ликвидации последствий аварии на ЧАЭС. Согласно данных анализа обращаемости за медицинской помощью (таблица 1), отмечено значительное количество лиц, имеющих признаки поражения ЛОР-органов.

ПТО
Чернобыльская АЭС
им. В.И. Ленина
ИНВ. № 390-РБ

Таблица 1

Обращаемость (в %%) за медицинской помощью лиц с явлениями поражения ЛОР-органов (данные з/п ЧАЭС) ~~[illegible]~~

Дата месяца	10.06-20.06.86	21.06-30.06.86	01.07-10.07.86	11.07-20.07.86	21.07-31.07.86	1.08-10.08.86	11.08-20.08.86	21.08-31.08.86	1.09-10.09.86
%% обращаемости по поводу заболеваемости ЛОР-органов	21,0	26,0	43,0	43,0	34,0	34,0	40,0	24,0	21,0

В среднем за декаду обращений: ~ 62[illegible] чел.

The Report Note

TP Dept. of the Chernobyl NPP, reg. # 390-RB of 16.09.1986

Preliminary results of study of contamination of workplace environments and ground-level ambient air of the Chernobyl NPP by some chemical components

In the period from 5.09.86 to 11.09.86, sanitary-chemical measurements were made in the air samples and wash-outs for detection of some chemicals of irritating and general toxic action in order to identify their potential health impacts on participants of works for liquidation of consequences of the Chernobyl NPP accident. Analysis of quantitative data of applications for medical assistance (Table 1) suggests a substantial number of persons with signs of affected respiratory organs. The average number of applications reached about 600 persons per 10 days.

I will not quote the whole document, and focus on the most substantive aspects. So, in 80 days, **five thousand complains** were registered in connection with the respiratory system. The complains peaked in July - the period of the most intensive decontamination works at the NPP site. Besides that, it is necessary to note that far from all people in need of medical assistance were able to apply for it. The majority of the military liquidators did not have such opportunities.

Table 1

Applications for medical assistance in connection with respiratory health problems (in %) (data of the primary health care unit of the Chernobyl NPP).

Days/mont-hs of 1986	10.06-20.06	21.06-30.06	01.07-10.07	11.07-20.07	21.07-31.07	01.08-10.08	11.08-20.08	21.08-30.08	11.08-20.08
Percentages of respiratory health-relat-ed applications	21,0	26,0	43,0	43,0	34,0	34,0	40,0	24,0	21,0

Accounting for activities on the site, physical and chemical properties of chemicals that were used in decontamination works in the course of mitigation of consequences of the Chernobyl NPP accident, levels of contamination of air and different surfaces by some chemicals were measured (see tables 2 and 3).

Table 2 contains information on levels of some chemical pollutants in workplace air and in the ground level air of the Chernobyl NPP site (lead, sulphur *dioxide, nitrogen oxides, hydrogen chloride, particulates). Lead levels in excess of MAC (maximal acceptable concentration) were registered in A&UB-1 and in the turbine room building* ***(in 1.5 times)*** *and in the ground level air at the Chernobyl NPP site* ***(more that in three times)****.*

Table 3 contained lead levels found at different surfaces in workplace environments and at the NPP site. Lead was found everywhere - its levels reached up to 0.12 mg per dm^2.

The following conclusion was made: "Preliminary sanitary and hygiene studies revealed … lead contamination of indoor workplace air and at different surfaces indoors and at the Chernobyl NPP site. Additional comprehensive studies are necessary to identify potential impacts of the chemical factor on the workers' health".

The Report Note was signed by Silantiev V.F. and Pshenicknova N.I. on behalf of R&D Institute of Food Hygiene and by the deputy Chief Engineer Karpan N.V. on behalf of the Chernobyl NPP. The document is dated 12.09.1986.

The Report Note was sent to all relevant organisations and to the Governmental Commission. I do not know why the academicians did not see it.

Graphite did not burn

Let us return to graphite "burning" in the initial days after the accident and to the nuclear fuel residues. The reactor initially contained 1760 tons of graphite and 190 tons of nuclear fuel (uranium dioxide). How much fuel and graphite did they find at the NPP site after the explosion?

Scientists were divided on the issue of graphite burning. The majority of them insisted that graphite burned. However, the most competent ones, who dealt with graphite professionally, had serious doubts in burning of the Chernobyl graphite. Academician Spartak Belyaev said in this connection: *"Many people were surprised to hear that graphite burned, as its ignition temperature is much higher than 2000 °C (the officially reported temperature of the active core). Some said that zirconium acted as a catalyst and that zirconium pipes should not be used in a graphite reactor. I am not a chemist by training but I explored the matter a little. Actually, graphite does not have a definite ignition point - it depends on a media involved. It is hard to identify unequivocally why it ignited. I do not exclude a possibility that in some locations within the active zone very high temperatures emerged, providing preconditions for graphite ignition. Maybe zirconium influenced the process somehow. We still do not have a complete picture of processes after the explosion. To tell the truth, this sphere of analysis of the Chernobyl accident lags behind others. Notwithstanding many experiments with graphite that were already conducted and many ideas discussed, we still cannot reconstruct* *these events in detail".* ("Nature" magazine (Rus.) # 11, 1990, Liquidation of Consequences of the Chernobyl Disaster).

After the accident, only 700 to 800 tons of graphite were recovered at Unit 4 - i.e. graphite losses reached more than a half of its initial amount. The most plausible explanation of the graphite loss is associated with its sublimation in the course of "nuclear" flash and its dispersion by the subsequent explosion (similarly to fuel). Contrary to the misleading assumption of graphite burning (the one universally known since 1986) specialists argue that graphite does not burn or melt even at temperatures of 3600 °C and higher, it simply sublimates. The exterior view of graphite blocks blown out from the reactor confirm the latter suggestion. At the Chernobyl NPP site, sublimation-affected graphite blocks were found that lost up to 50% of their initial mass, as well as huge amounts of graphite dust covering the NPP site. Graphite dust was found at distances up to 200 km from the Chernobyl NPP, including locations nearby Kanev [Article "Experimental Study of the Destroyed Reactor", K. Checherov, PRIPYAT web-site].

Control and shutdown system rods in the nuclear explosion area also evaporated, i.e. they shared the fate of graphite and nuclear fuel.

The reference note on study of graphite burning *(K.P. Checherov, "Unpeaceful Atom of the Chernobyl", "Chelovek" magazine, # 6, 2006 - # 1, 2007):*

"In summer 1986, experiments were conducted to check possibility of graphite burning in the active core. In the Radiation Material Studies Dept. of IAE, Fedor Fedorovich Zherdyaev heated pieces of reactor-grade graphite in a muffle furnace to a red-hot temperature, but after their removal from the furnace they immediately turned black and did not burn. In NIKIET **, Vladimir Nikitich Smolin conducted a series of experiments with video-recording. In the course of one such experiment, graphite blocks were placed on birch-tree firewood in a barrel (200 litres) covered by asbestos (for thermal insulation of graphite) and without a bottom (to ensure air access). The firewood burning heated the graphite to a red-hot temperature. The video-camera recorded changes of dimensions of heated graphite blocks in the barrel for several hours. No flame was observed, but graphite sublimated gradually: a few hours later, some changes of form of the graphite blocks were visible, however, after removal of a heated graphite block from the barrel, it immediately cooled, notwithstanding a free access of the oxidiser to the graphite.*

That experiment and other ones confirmed that graphite loses its mass if heated to a high temperature. But even in conditions of excessive inflow of the oxidiser, in the air, at high initial temperatures, graphite does not sustain a flame burning, the reaction is not a self-sustaining one. After depressurisation of the active core graphite was in conditions similar to ones in the above experiments: no thermal insulation, no external energy supply, and free access *to air. No cases of burning graphite were observed when graphite blocks were blown out onto the NPP site at night of April 26, 1986.*

[*] I.V. Kurchatov Institute of Atomic Energy; "Kurchatov Institute" Russian R&D Centre since ñ 1991.

[**] N. A. Dollezhal R&D Power Engineering Institute.

How much nuclear fuel does the Sarcophagus contain?

The search for residual nuclear fuel after the explosion was launched in summer of 1986. These activities were conducted by radiation monitors and physicists of the highest qualification, who had all the necessary equipment to work in dangerous conditions. They had finally managed to resolve that fantastically difficult problem, but it took more than ten years. Finally, they estimated the amount of residual nuclear fuel after the explosion. According to reports of Konstantin Checherov, who led that team of specialists, not more than 50 tons of uranium are present in buildings of the Chernobyl NPP, including 118 irradiated fuel assemblies in the southern INF cooling pond and 48 new fuel assemblies in the central reactor room at the in-house storage. I should note that one may reliably estimate the amount of fuel that had actually "flown" outside the NPP site due to the reactor explosion only as the difference between the initial reactor fuel load (190 tons) and the actually identified uranium in the reactor unit building, at adjacent roofs and at the NPP site (about 50 tons). The difference reaches 140 tons (the "flown-away" nuclear fuel). An attempt to estimate the amount by deducing the amount of dispersed uranium that was found in fallout (7 tons) could result in 20-fold error. The latter assessment option does not account for the fuel that evaporated at the stage of the nuclear explosion and fails to cover the whole area of the Chernobyl-generated fallout. However, notwithstanding inadequacy of the second approach, the official structures has been relying on it since 1986, declaring that "now, we can consider it proven that, at the level of confidence of 0.63, more than 95% of nuclear fuel from the initial fuel load remains inside "Shelter" facility, that covers Unit 4" (*the estimate of amounts of fuel and radioactive substances released in the course of the accident from Unit 4 and remaining inside "Shelter" made at the base of "The Safety Report of 'Shelter' Facility", 2002*).

Indirect methods, applied by "political science" to support that inadequate estimate - the ones based on estimating the amount of fuel by its radioactivity and heat generation - produced even more inaccurate results. As an example, I will refer to the attempt to install 18 m high pipe with temperature and gamma radiation sensors into the reactor shaft (the pipe was called "Igla"(needle). Scientists set high hopes on the “Igla” installation operation conducted on June 19, 1986, as a result, helicopter crews “hovered” over the reactor debris longer than usual, getting excessive radiation doses and trying to install “Igla” precisely into the requested point. Finally, “Igla” was installed and its sensors started to supply information. Temperatures and EDRs were registered on board of the helicopter. One can see protocols of these measurements even now. According to the “Project of Burial of Unit 4 of the Chernobyl NPP” - “results of ‘Igla’ measurements of radiation fields in the active core were used to produce estimates, suggesting that the bulk of remaining fuel in the reactor unit is located inside the reactor shaft, reaching 10 to 30% of the overall fuel load”. However, a survey of the central reactor room, made two years later, revealed that “Igla” missed the reactor shaft altogether - it was installed into the empty (northern) INF cooling pond, that never contained any fuel both before the accident and after it [Article “Experimental Study of the Destroyed Reactor”, K. Checherov, PRIPYAT web-site].

Estimates of the area of the reactor active core, where excessive reactivity released that caused the nuclear explosion, suggest that about 10% of the fuel participated in the explosion. These estimates do not contradict to the assessment of the explosion yield of 30 tons TNT equivalent (the assessment was made by KGB specialists). Fuel that was evaporated and strongly dispersed (to micrometre range particles) in the explosion area, was ejected to the atmosphere. The rest of the fuel was partly dispersed, partly fragmented and blown out from the reactor.

A reference note on the fuel

Presentation of A.N. Kiselev and K.P. Checherov - “The Process of Destruction of Chernobyl NPP Unit 4 Reactor” - at the Ministry of Emergency Response Conference on “Overcoming Consequences of the Chernobyl Accidents. Conclusions and Prospects”, May 2001 suggests: “Due to complete loss of water in the active core and runaway of the reactor, temperatures of nuclear fuel in the critical area of the active core reached about 40,000 °C. Fuel dispersed and evaporated (in the active core) while a substantial part of graphite blocks also dispersed. Gaseous products and highly dispersed particles reached the stratosphere.

In compartments under the reactor, the melt of fuel and construction materials flew - the melt reached these compartments due to destruction of some parts of the supporting concrete plate of the reactor shaft. Later on, not more than 9 - 13% of the initial nuclear fuel load of the active core were found in the cooled and solidified melt. According to the radioactive release estimates, made in Chernobyl on 24.05.86 by leading specialists of the Ministry of Medium

Machine-building Industry (MMMI), the explosion ejected 15 - 25% of fission-generated radionuclides and the fuel outside the Chernobyl NPP site, about 25% within the NPP site and about 5% into the debris of gas tank ERCS (emergency reactor cooling system). No nuclear fuel left in the reactor shaft. Summing up: about 32% of the fuel released to the atmosphere, evaporated and dispersed into sub-micrometre range particles".

Whom has the science beaten?

Let us make some conclusions: the explosion evaporated and partly dispersed fuel and graphite - resulting vapour and fine particles of the sub-micrometre range were spread later throughout the World. After the accident, not more than 800 tons of graphite and not more than 50 tons of nuclear fuel remained at the NPP site. The central reactor room of Unit 4 building was predominantly filled by construction debris and materials dropped into it from helicopters. The decisions, that were made at the base of inadequate assumptions about physical and chemical processes in the damaged reactor unit, finally proved to be inefficient and even detrimental. These decisions resulted in additional damage of Unit 4 constructions, in extended duration and intensity of radioactive releases and in a large-scale radiation over-exposure of people.

Well, but what forced scientists to recommend such poorly considered decisions to the Governmental Commission? In this connection, V.M. Fedulenko, the leading research associate of the Institute of Safety of Atomic Energy Use, recalled excusatory words of V.A. Legasov: *"People will not understand us if we will do nothing…". (Fedulenko V.M. "ChNPP: the Accident that Has Shaken the World").*

K.P. Checherov, a physicist from Kurchatov Institute, explained the matter frankly and with knowledge of the facts involved: "No information on real state of the reactor and the whole reactor unit after the accident, universal unpreparedness to an off-design NPP accident provoked fears of explosions and disastrous events at all levels. According to published memoirs of A.N. Semenov (the deputy Minister of Power Industry of the USSR in charge of capital construction matters), the Sarcophagus concreting operations were not launched as planned by the Governmental Commission due to fears of E.P. Velikhov, *"that if pieces of nuclear fuel will become trapped in the concrete mixture, when the concrete will solidify, the resulting construction will act as an atomic bomb with explosive yield proportional to the amount of the nuclear fuel trapped inside the concrete".* A.P. Aleksandrov had managed to find words to convince E.P. Velikhov and the concreting operation was launched finally, however, from the initial days of the Sarcophagus concreting works we often observed boiling and geyser-like eruptions in the newly filled concrete mix. I thought that the concrete was overheated by hot fuel assemblies (we all wanted to find them but did not see their fragments before the mortar injection). Later on, experienced construction specialists explained us that if concreting operations are conducted in violation of the applicable standards, a concrete mixture starts to overheat and boil"[8].

The non-stop decontamination of the Chernobyl NPP site and nearby areas that was conducted up to September 1986 without much success, also was hardly sensible. A special decision of the Governmental Commission was necessary to cancel all decontamination operations at the NPP site due to the endless secondary contamination (except indoor decontamination operations and decontamination works directly associated with construction of the covering Sarcophagus over Unit 4 reactor).

In this connection I recall a conversation in daytime of April 26, 1986 in the underground command bunker at the Chernobyl NPP site. I discussed results of spectrometry measurements with Vitaliy Perminov, the chief of our spectroscopy laboratory (also a former MMMI employee, like me). He got these spectroscopy results jointly with his deputy Anatoliy Sukhetskiy and the results demonstrated presence of nuclear fuel in air, water and soil samples. Assessing future prospects we came to the conclusion that the NPP should be better decommissioned forever and only nuclear safety works should be maintained on site. Residents of contaminated areas should be also evacuated permanently. Natural self-cleaning processes should be allowed to develop uninterrupted for at least thirty years. Otherwise, unreasonably large numbers of people would suffer… Naturally, those were just thoughts of two ordinary engineers who faced an extreme accident, and they did not pretend to represent a strategic approach.

We will not become slaves of the atom

Coming back to normal life

I recall now the NPP recovery works and preparations to relaunch the intact reactor units as an endless grey succession of working days.

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[8] *Tr. note. Concrete solidification reactions are accompanied by a substantial release of heat. Unless removed, the heat may damage a construction being filled, therefore, if massive concrete items are constructed, special cooling pipes are inserted into the solidifying mixture to remove the excessive heat safely by circulating water*

It was like an endless circle chase - forward, forward and quicker! All life was dedicated to work. The NPP personnel resembled a well trained and united dog sled relentlessly covering thousands miles in infernal conditions of Alaska winter…

Up to May 27, the NPP actually operated without a director, as V.P. Bryukhanov was in the focus of endless investigations. The new NPP director was appointed - E.N. Pozdyshev, the deputy Chief of "Soyuzatomenergo" from Moscow. Prior to his transfer to Moscow, Erik Nikolayevich Pozdyshev, a graduate of the Physical Department of Leningrad University, rather successfully operated as the Director of Smolensk NPP. He was a very good choice for the new chief manager of the NPP, he had a substantial professional experience (26 years), who knew how to work in extreme conditions and liked such work. He planned his work masterly and always did what he promised. He worked for 14 hours in a day and managed to make the NPP personnel to follow suit. People believed and respected him, because in addition to his successful professional work he also managed to address pressing social and household problems of the NPP personnel, including provision of housing, return of families from evacuation, provision of assistance in settling household problems in new places. Under his management, the NPP was radically improved - it was cleaned from radioactive contaminants to the maximal extent possible, indoor facilities were refurnished, canteens with excellent meals were established and all problems with workwear were resolved. When specialists from other NPPs visited us, they were impressed by the "gold" corridor to control rooms of reactor units and by clean toilets as well.

By September 1986, flats in Kiev were provided to out personnel. Kiev was the only city with the necessary number of new residential blocks, that were constructed that Summer after the accident. We understood that these arrangements substantially extended the waiting list of Kiev residents who expected resettlement to new flats. But at that time, the authorities simply did not have any other option to house the team of workers who made their hard and dangerous work at the NPP site in a compact manner. The flats were provided to us temporarily, and we were temporarily registered[9] in Kiev.

We were very happy that many months of unsettled life of our families had finally ended and we got housing at last! The state

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[9] *Tr. note. The Soviet system of residence registration (so called propiska) was used by the authorities to restrict population mobility. It was not a mere registration it was an authorisation to live in a particular place*

authorities did not spare money to compensate property we lost after the accident and assisted us to purchase necessary furniture and household items. Our children attended schools and kindergartens, wives gradually got employment. Our life normalised and we were able to focus completely on reconstruction of the Chernobyl NPP and on preparing its intact reactor units to relaunch. The Politbureau of the CPSU Central Committee and the USSR Government decided that the NPP should generate electric power. The NPP personnel, hardened by the heavy ordeal, could tackle and really fulfilled tasks of any complexity. By late 1986, two reactor units of the Chernobyl NPP had been decontaminated and operated. At that time, all sections and services of the Chernobyl NPP functioned as a precious Swiss chronometer.

Almost all NPP personnel worked on a rotational basis - two weeks of work on the site (12 hours/day) followed by two weeks of rest in Kiev, with families. In the course of 2 weeks of work, the team personnel members lived in "Green Cape" townsite that was constructed in the Summer, at the boundary of 30-km exclusion zone.

"Green Cape" townsite

The NPP Director, the Chief Engineer and their deputies worked and stayed there permanently, without the luxury of 2-weeks breaks for rest. They were lucky if they managed to take three or four days off in a month. In some months they did not have any day off. As I was a deputy Chief Engineer at that time, I was almost completely separated from my family, and I had a dream to break the extremely exhausting daily routine of the NPP management. Once I almost succeeded - now I will tell how it happened...

The Governmental Commission

In September 1986, despite his long-term hardening exercise and daily jogging, our new Director E.N. Pozdyshev fell ill. It was a result of intolerable stress, accumulated fatigue and radiation exposure. He had looks of a recumbent patient but he remained in his office fulfilling his service duties. After a morning briefing with the NPP sections' chiefs, he asked me to replace him and report to the tomorrow's meeting of the Governmental Commission that held its sessions in Chernobyl twice a day. I agreed as on that day the Commission's session agenda incorporated also my own report on matters of improvement of operation of the radiation exposure monitoring service. The session was chaired by the Commission's Chairman B.E. Scherbina - it was his another turn to work in Chernobyl. Deputies of the Chairman of the USSR Council of Ministers also rotated at intervals of several weeks, similarly to the NPP personnel. Rotating chairmen and other members of the Governmental Commission sometimes introduced nervousness into our continuous work routine. Every particular Chairman had his own style, communication pace and management methods. Everyone of them had his own opinion on work of the NPP personnel and personal contribution of the NPP top managers. Starting another duty tour to Chernobyl, every Chairman tried to accelerate the recovery works, particularly in connection with decontamination of the NPP site and 30 km exclusion zone. If the accident mitigation works encountered problems due to lack of professionalism of some managers - even ones of the ministerial rank - the session room of the Governmental Commission transformed into a battlefield. Sometimes, generals lost their stars in these battles and experienced grey-haired ministers started to stammer and approached the brink of a heart attack.

On the day, when I had to report for myself and on behalf of the NPP Director, B.E. Scherbina planned to "teach" top managers of the Chernobyl NPP. The session room was filled by ministers from Moscow and Kiev, directors of research and industrial organisations and generals of different calibre. The atmosphere of the session was fairly tense and nervous, as all the participants knew too well that the Chairman is a master of heating sessions to the state of extreme tension. After "warming-up" a little on military representatives and making them sweat, Scherbina announced discussion of the NPP-related problems. When I came to the speaker's stand and started to hang charts, I got the first salvo from the Chairman addressed to my back: "Why doesn't the NPP Director report? I want to see the Director and hear him reporting on the deadlines missed!" Academician Valeriy Legasov (we contacted sometimes on business matters), who sat on right side near Scherbina, whispered him: "According to the session agenda, today, the keynote report will be presented by the deputy Chief Engineer Karpan. We have to decide on human resources". Scherbina knitted his brows and told me to start. I started to report with use of visual aids - charts and graphs. In the course of my presentation, nobody had any questions. Only Scherbina suddenly asked: "When will 'Green Cape' townsite be fenced by a normal fence? When will your director come in person to the Commission sessions instead of sending his deputies? When will you finally install the computer to process radiation monitoring results?" I answered that first two questions were outside my sphere of competence, while computer-related requests were already submitted to his assistant. We were ready to install the already ordered equipment and people were ready to use it.

Scherbina turned to his assistant Yu.D. Proferansov and asked him "where is the computer?" The assistant demonstrated a fantastic art of clearing himself: "Yes, I remember the request, we forwarded it to the computer manufacturer. The manufacturer responded that the plant does not produce such computers, but they produce similar models, with the same model code but with a dot after the third digit in the model code. The request should be adjusted". Scherbina started to press me further: "When will you learn to compile equipment requests duly? When will you start working orderly? When will the fence appear at last around 'Green Cape' townsite?"

Legasov felt that the situation went wrong, he bent towards Scherbina and said: "Boris Evdokimovich, these issues are really outside his sphere of competence". Scherbina was not cooled by his words even a little bit, I saw it clearly. I should have better kept silence, but I was so surprised by Proferansov's answer that I blurted out: "The computer request form was compiled duly, and we discussed the supply with the manufacturer preliminary. There are no problems between us and the plant, I can prove it. As for the fence, it is the construction workers' responsibility, not ours."

They did not allow me to say anything more. Following a model demonstration style, using heavy verbal artillery and applying firm emotional pressure Scherbina cursed me for all shortcomings of the NPP top managers and completed his exercise by the following words "For edification of other managers I dismiss you from your job, the dismissal is effective from this day!"

I thought that at least I would have a rest and thanked Scherbina for such a suddenly emerging chance to relax after two months of incessant work. Then I left the session room - now quiet - and returned to my work. When I just entered my office, I was immediately asked to answer the phone call in the reception room - Proferansov called to invite me to a personal meeting with Scherbina, scheduled to 2 p.m.

and take monthly personnel radiation exposure forecasts and documents on issues in my sphere of competence that need to be decided on urgently. I had sufficient time to prepare to the meeting, so I additionally prepared a draft decision of the Governmental Commission. The draft proposed to introduce additional paid positions of the NPP Director, the Chief Engineer and their deputies - the new arrangement would allow us to work on a rotational basis and have a rest, like all the other personnel involved (including members of the Governmental Commission).

At 2 p.m., accompanied by Yu.D. Proferansov, I entered the office of the Chairman of the Governmental Commission. No other persons were present and nobody intervened in the course of our conversation that calmly continued for an hour or so. B.E. Scherbina was fully satisfied by the documents provided and by my explanations. He did not make any critical remarks on my work. Moreover, when I proposed him to look through the draft decision of the Governmental Commission (the one I prepared in advance) he just laughed and signed it, adding that the document would be categorised as “Secret”. Them I departed. I went to the NPP to meet E.N. Pozdyshev and tell him how I was “fired for the fence the Director failed to construct”. He listened to my story with close attention. Having realised that the threat to the Chernobyl NPP from the Commission Chairman was defused, the Director cheered up. He had tense personal relations with B.E. Scherbina, who really tended to rely heavily on criticising his subordinates publicly, squashing them morally. But sometimes, when he realised that he acted in a clearly unjust manner - like in my case - he swiftly corrected his mistakes.

In this connection, at a next session of the Governmental Commission, I observed a real surprise on faces of the session participants, when - having been fired earlier - I made a report and B.E. Scherbina positively assessed the pace of our works.

By the end of that week, the NPP Director invited me to his office and said: “Scherbina failed to fire you and you did not go home. Now, I “order” you - you can leave the NPP for 48 hours. Consider it as a bonus”.

I quickly made necessary arrangements, took a dose-meter with me and went to Kiev. My family was happy and only one thing made us worry - I identified several tens of places in the new flat with high radiation levels. Such radiation hot spots were particularly plentiful in the children’s room with its windows to the North-west. Radiation sources were located in walls, in wooden window frames, the doors and the parquet. I had to remove these radiation sources urgently - radioactive dust particles, blown to Kiev by winds from the Chernobyl NPP area in summer months, when the house was under construction and stood without windows, doors and the roof.

Having returned to the NPP after two days off, I had to initiate examination of “radiation safety” in flats of out staff members. It was not a particularly difficult task, as one of Ukrainian radio-equipment plants had already launched production of simple IRK dose-meters (the instrument was designed by Vladimir Varchenko, an engineer of our Nuclear Safety Dept.) The NPP purchases a batch of such dose-meters and issued them to staff members. Armed by IRKs, the NPP workers themselves cleaned their flats with particular care. However, the story of “bad flats” did not finish at that stage. When we had accumulated a sufficient body of statistical data on radioactive contamination of residential flats, we realised that the situation was not associated with particular cases only, we faced the problem of a large-scale radioactive contamination of all newly constructed residential blocks in Kiev. In this connection, we drafted proposals for the Governmental Commission and I reported their contents at one of sessions of the Governmental Commission. We proposed to introduce entry radiation control of construction materials (sand, timber, gravel, etc.), as many sand pits and timber production facilities were contaminated by Chernobyl releases.

Our information generated a mixed response. Some sympathised to the NPP personnel, some others remained indifferent to the “minor” problem that was not worth attention of the Governmental Commission. However, the most surprising response came as a letter of Kiev City Executive Committee. The letter claimed that the city Sanitary and Epidemiological facility initiated checking of flats provided to Chernobyl personnel and in five flats radioactive belongings of the residents were found. Accounting for the findings, the Executive Committee concluded that residents themselves contaminated their flats, as well as adjacent areas nearby their residential blocks. We had to check their data (fortunately, the letter specified addresses of “dirty” flats). Our checks allowed us to ascertain that three flats from the list were still empty, while residents of two other flats said that no inspectors from the Sanitary and Epidemiological Facility had ever visited them.

We exposed the come-off of Kiev city authorities, but the main result of these events was associated with establishment of radiation control laboratories in the sphere of housing construction in Kiev.

Unfortunately, the Governmental Commission had failed to arrange a “reserve team” of the NPP top managers to relieve us and we continued to work practically without rest. Though, chief managers from other NPPs were seconded to the Chernobyl Power Plant to support us.

How they tried to enslave us to the atom

Having looked through my working notes of 1986 - 1988, I decided to provide a brief outline of the events that resulted in disintegration of the NPP team of staff members who worked as a well tuned instrument. In one year (from mid-1987 to mid-1988) they managed to destroy the team that went through hard times of the explosion of Unit 4, many months of separation from families, extremely hard work to mitigate the accident consequences and relaunch two restored reactor units.

I am still convinced that the Chernobyl NPP should not have been restored after the Unit 4 explosion. However, the CPSU Central Committee and the USSR Council of Ministers could not tolerate the loss of four operational reactor units and two reactor units under construction of the NPP, and mobilised huge resources to restore them. More than 650 thousand people went through the radioactive Chernobyl zone, losing their health there. Some did it voluntarily, but others - in larger numbers - simply obeyed orders of their superiors or were conscripted by Military Commissariats.

The Soviet propaganda machine worked efficiently to calm people. Mass media outlets published photos of diverse robotic mechanisms operating under intensive radiation exposure. Photos in newspapers demonstrated lead-clad cabins of cranes, bulldozers and trucks. Heroic efforts of doctors who saved victims of radiation exposure were much praised. Media sources described good living conditions of people who worked at territories affected by the radioactive fallout, praised excellent food supply and throughout radiation exposure control. According to the media reports, workers were immediately relieved of their professional duties if their radiation exposure doses approached admissible margins. All these reports may be even considered true, albeit partly, but only in the case of the Chernobyl NPP core personnel and skilled specialists who were seconded to the NPP. However, there were other workers as well - people of different specialisations from all regions of the USSR, who were called up by Military Commissariats and were used for many months as unskilled labour both at the NPP site and in the exclusion zone. Their living and labour conditions were radically different comparatively to ours, and in many occasions I saw it with my own eyes. Some of them had to work in mortally dangerous conditions, for example, in the course of cleaning roofs nearby the destroyed reactor unit.

After completion of their hard work, conscripted and civilian “liquidators” of the accident returned to their republics, cities and villages. But the Chernobyl NPP personnel had to stay in the Chernobyl zone permanently to maintain the NPP operations. We did not object to such a decision. The authorities promised to construct a new city for the power plant personnel in Kievskaya oblast and proposed two alternative sites to choose from. One of the sites was located nearby Dymer (Glebovka township), while the other one was located at the bank of Kiev Water Reservoir nearby Strakholesye township (at the boundary of the Chernobyl exclusion zone). The NPP personnel agreed to the both sites. We did not cling to Kiev and continued to work calmly and intensively, having no idea that the Politbureau of the CPSU Central Committee and the USSR Council of Ministers were preparing plans to alter our lives radically.

On February 2, 1987, after the successful relaunch of two reactor units, M.P. Umanets (the former Chief Engineer of the Leningrad NPP) replaced E.N. Pozdyshev as the Chernobyl NPP Director. The new director had two tasks to accomplish - to restore and relaunch reactor Unit 3 and gradually transform the NPP status from the accident-ridden to the standard operational one (the status it had before the accident). The new NPP Director, a vigorous and ambitious man, an expert in communications with superiors and subordinates, was ready to accomplish the first task. But even Heracles would fail to accomplish the second one and to reduce radiation exposure of the NPP personnel, working in the epicentre of the nuclear explosion, to the pre-accident levels.

The country's rulers decided to review our living conditions as well. Two earlier selected sites for construction of the NPP township were rejected. According to a proposal of B.E. Scherbina, construction of Slavutich town was launched at a new site, located father away from the NPP, in Chernigovskaya oblast, nearby Nedanchichi village. The new option extended the necessary time to transport workers to the NPP site up to several hours per day. In addition, the new town was located in the centre of a huge radioactive caesium fallout spot. As a result, living conditions of the NPP personnel and their family members were radically worsened. Tensions started to rise among the Chernobyl NPP staff members. These tensions developed into a conflict of two forces - the well hardened team of NPP personnel and gerontocrates of the CPSU Central Committee.

We realised that in the case of a nuclear power plant, it is responsible and professional staff that may guarantee the plant's safety. A poorly trained team may blow up even a steam engine, that is why NPP personnel selection procedures are so strict. We were ready to continue working at the NPP up to the pension age or even longer. We were ready to train young specialists. But we could not afford to endanger live and health of our family members who were forced to resettle with us to a radioactively contaminated area. As a result, we started to object the planned resettlement to Slavutich.

We had failed to reach a compromise in our opposition to the decisions made by the country's rulers. All our proposals to maintain the experienced team of the NPP personnel who worked there before the accident were rejected. "Wise old men" from the Kremlin decided to press us comprehensively. We were pushed about at Party meetings, we faced threats of wholesale personnel lay-offs. The authorities did not take us into the consideration any more, for them we were just "Moors who have done their duty" and returned the Chernobyl NPP back to life. Something was to break, either the Party plans or the will of the NPP personnel.

We did not break. We were fired in batches by orders of M.P. Umanets, the new NPP Director, people lost their favourite work, but they stood firmly for their case. Less than 10% of the pre-accident NPP personnel resettled to Slavutich, mainly young people who were hired in 1984 - 1986.

In that situation, the Politbureau and the USSR Council of Ministers had not won. The NPP operated only for 12 years after replacement of the personnel. On December 15, 2000, the Chernobyl NPP ceased to generate electric power. The town of Slavutich continued to exist without its sole source of income. The town residents became hostages of the policy pursued by the Politbureau of the CPSU Central Committee.

Readers themselves may decide whether my conclusions are correct at the base of the below facts of our life in that period of time.

Our confrontation started from disclosure of plans of the Politbureau of the CPSU Central Committee and a next negative assessment of the NPP personnel team.

7.01.1987. The visit of V.I. Dolgikh, a Secretary of the CPSU Central Committee, a candidate member of the Politbureau, to the Chernobyl NPP site

Dolgikh V.I. "The accident at the Chernobyl NPP was caused by the personnel's danger fatigue, by underestimation of risks in cases of non-compliance with the Operational Regulations. Decontamination is now the key task at the NPP site. The best available science should be mobilised to this end. The Chernobyl NPP personnel fostered a psychology of passive waiting, as a result, no technical proposals are developed there. The whole country cares, but you display some elements of passivity. So, you should prepare themselves to a review of your remuneration arrangements, to lower wages. Remove excessive workers. Stop your workplace bravado and heroism under radiation exposure. We will establish a commission of the Public Health Ministry, the USSR Trade Unions Council and the Ministry of Nuclear Power Industry that will closely check how you issue N-1 forms. We will provide assistance to the ones with high exposure doses. The NPP personnel should prepare for resettlement to Slavutich".

15.05.1987. The session of the Board of the Ministry of Atomic Energy at the NPP site

The NPP Director M.P. Umanets reported on the course of decontamination of the NPP buildings and repairs of the equipment associated with relaunch of Unit 3.

The military reported on the course of decontamination of the NPP site: "We are completing the burial of the Red Forest. We have demolished constructions at 4 hectares, in the equipment station and the construction site. Two thousand vehicles have not been decontaminated yet".

Minister Lukonin N.F. "The situation is alarming. Designers should overtake arrears in work. The whole territory of the zone is littered, it is the fault of all the parties involved - the Ministry of Medium Machine-building Industry, the Ministry of Defence, the Ministry of Power Industry and the Ministry of Nuclear Power Industry".

Then, the course of construction of the town for the NPP personnel - Slavutich - was discussed. The Chief of the Construction Directorate **Kizima V.T.** "We will build everything, including sales outlets and canteens. Maybe they will not be ready tomorrow, but we will surely complete them in June. The town is not convenient for life as we build it as a whole, instead of separate sections. The first residents, who will resettle to Slavutich this year, will face difficulties".

Umanets M.P. "In the course of 4 months, more than 600 persons accumulated the half-year exposure dose, about the same number of personnel accumulated 80% of the annual dose. Three persons got more 25 rem (0.25 Gy). In this connection, we need 1105 extra workers from other NPPs. Now, we have the workforce of 6535 persons, accounting for the rotational work arrangements and 12 hours workdays. The Chernobyl NPP has a personnel shortage of 2100 persons. People come to us, Chelyabinsk provides well trained personnel, but we have no residential space to accommodate them. I consider abandoning the rotational arrangements as a solution".

Minister Lukonin N.F. "Visit me by the end of the month with proposals on workforce reduction and reduction of exposure loads."

Komarov V.I. (the Chief Engineer of "Kombinat" Facility): "When snow melted, the background radiation level in the zone increased in 1.5 - 2 times. At the Chernobyl NPP site it increased in 3 times. Levels of radioactive particles increased in 100 times.

In Slavutich, at the cleaned construction site, the background level reaches up to 40 μR/hour, while in the surrounding areas the level reaches over 70 μR/hour (0.7 μSv/hour). A heavy beta-radiation is observed - over 2000 beta-particles per square centimetre in a minute".

Information note*: Before the accident, the background radiation level in Slavutich area reached 0.1 μSv/hour (up to 0.02 Sv/hour after the accident but before the decontamination works). Acceptable skin surface contamination for NPP personnel (A category) was set in the USSR Radiation Safety Norms RSN-76 at the level of merely 100 beta-particles/cm^2 per minute; while for a limited part of the general population (B category, residents of Slavutich) the acceptable limit was set as 10 beta-particles/cm^2 per minute. In Slavutich, the latter limit was exceeded in 200 times.*

Minister Lukonin N.F. "It is our fault that contaminated machinery, materials, clothes and so on enter Slavutich. Komarov, draft an Order for my signature, prohibiting any organisation, any ministry to deliver any contaminated item to Slavutich, without your authorisation".

7.07. 1987. The court session in Chernobyl: the NPP top managers are charged

Notwithstanding that the investigation of causes of the accident (the one completed in 1986), recognised that RBMK reactor is explosion-prone and has some unacceptable design failures, the real authors of the explosion were not charged. The court decided that the NPP personnel are guilty in all adverse effects - including the explosion of Unit 4 reactor, the death of 6 firefighters and ever-exposure of Pripyat residents. Extracts from the court ruling claim:

"Irresponsible attitudes of the NPP personnel and top managers ... to ensuring nuclear safety, together with insufficient professional training of the operational staff members, who operated complex power-generating installations, had resulted eventually in the accident of April 26, 1986…

The chief NPP shift manager Rogozhkin did not guide the accident-mitigation works, he did not coordinate actions of the NPP shift personnel and specialised services, as a result, firefighters … Pravik, Kibenok, Tishura, Ignatenko, Vaschuk and Titenok got high radiation exposure doses and died later from acute radiation sickness …

… due to the fault of Bryukhanov and Rogozhkin, measures were not taken for protection and timely evacuation of the NPP personnel and residents of the nearby zone…"

The court is described in more details in the next part of the book. That part also provides results of investigation of causes of the accident that were reported on July 3, 1986, at the session of the Politbureau of the CPSU Central Committee. We clearly understood that the charges against us were cooked up and contracted and these factors additionally fuelled our opposition to the Politbureau's policy.

22.10.1987. The meeting of communists of the Chernobyl NPP (Green Cape township)

The meeting started from calm and business-like discussion of current operational matters. Them, the meeting participants started to discuss the issue of resettlement to Slavutich.

Umanets N.P. "The NPP Administration insufficiently dealt with the issue of Slavutich. The draft Settlement Regulation is ready. It is not sufficiently clear, what will happen to our benefits by the end on the 5-years period. The matter will be finally settled after the session of the Task Force of the Politbureau of the CPSU Central Committee... We will be switched to a new system of remuneration. Some wages will be increased as well, but the increase is conditional to making the NPP profitable in conditions of self-financing… I feel, that the personnel discipline faltered. We will apply very strong sanctions. But that is not the matter that concerns me most of all, I am more concerned by the ones who work waiting for their eventual discharge. They are silent and agree with everything, it looks like a quiet sabotage".

6.01.88 The visit of a brigade of the CPSU Central Committee to the Chernobyl NPP

The brigade incorporated: Babanin V.M., Piruev A.V., Mokhnatkin A.N., Shnutov V.S., Sokolova L.A., Afanasyev B.A., Kononenko V.F., Litvinov O.N., Belichenko A.N., Udovichenko V.P., and Sishov S.S.

They visited us to inform the NPP personnel on Decree of the CPSU Central Committee and the USSR Council of Ministers on Remuneration and Benefits for Persons Working in the Exclusion Zone.

Piruev A.V. "Since October 28, the Politbureau studied the remuneration situation at the Chernobyl NPP and the issues pertaining to resettlement to Slavutich. Therefore, my today's words will reflect results of well considered works, already reflected in the Decree of the CPSU Central Committee and the USSR Council of Ministers of 27.12.1987 and in the Order of Minister Lukhonin:

1. Since 1.01.88, for three following years, wages will be paid at double rate (in 1986, we were paid at five-fold rate - N.K.). Benefits are set as 60%. Work in night-time will be paid for at 35% extra rate.
2. To authorise chief managers of facilities and organisations to apply triple remuneration rates in exceptional cir-

cumstances and for limited periods of time (to be agreed with the Ministry of Nuclear Power Industry).

3. To establish a shorter 6-hours work day for persons who work in the exclusion zone.
4. To account for the period of work at the Chernobyl NPP with the factor of 1.5 according to List # 1.
5. To pay disability pension benefits according to the legislatively set procedures (if disability is associated with the accident consequences)".

The above provisions were the key ones, overall there were 14 provisions. As CPSU Central Committee Secretary V.I. Dolgikh promised earlier, our remuneration arrangements were reviewed to lower our wages. Plans of the CPSU Central Committee stipulated that by 1991, the Chernobyl NPP should not differ from other NPPs, neither in terms of personnel work hours, nor in terms of remuneration.

Babanin V.M. "Since 11.01.88, the Board will become operational to manage resettlement of the Chernobyl NPP personnel in Slavutich. The Board will incorporate representatives of the Ministry of Nuclear Power Industry, the USSR Trade Unions Council, etc. There are official documents of the Ministry of Public Health, the State Committee for Hydrometeorology, etc. on Slavutich and the surrounding area - the documents suggest that the radiation situation there is normal. In two nearest week, a group of specialists from the Institute of Biophysics, the Public Health Ministry and the State Committee for Hydrometeorology will visit the Chernobyl NPP - they will have tables, certificates and data on Slavutich and will be able to provide any information. The group will be seconded by the CPSU Central Committee. Naturally, there are some risks of contamination of Slavutich by people who work at the NPP site and in the exclusion zone. Such cases were observed in other cities".

Umanets M.P. "On behalf of people who gathered here, I would like to express our gratitude to the CPSU Central Committee for the high assessment of our work. The documents mentioned here agree interests of nuclear production with our interests to the most possible extent. Some our proposals were not accounted for, but we cannot anticipate all social implications of our proposals. Therefore, we were corrected. I think that these documents reflect the highest wisdom of the State and the Party. I express my personal gratitude to the Ministry of Nuclear Power Industry and the Party authorities that entrusted me to lead the NPP further. I will resettle to Slavutich, like all others. I believe that we need permanent workers, not temporary ones".

After these events, associated with alteration of our remuneration arrangements and plans of the CPSU Central Committee to force the NPP personnel to resettle from Kiev to radioactive Slavutich, skilled and experienced staff members of the Chernobyl NPP started to quit.

10.02.1988. The operational briefing of the NPP Director

Tsarenko I.N. "In a week, 20 people quitted, but recruiting of personnel from other NPPs has progressed. We have already sent 30 new specialists for medical examinations. The Ministry of Justice, the Ministry of Nuclear Power Industry and the USSR Trade Unions Council are drafting a document to regulate procedures of discharge of the Chernobyl NPP staff members who do not want to resettle to Slavutich. The number of cases of asocial behaviour sharply increased".

Shteinberg N.A. "In 1987, 388 equipment malfunctions were registered at the Chernobyl NPP. Quality of training of new personnel sharply declined".

12.02.1988. The session of the Governmental Commission

The NPP Director **Umanets M.P.** provided a brief report on the situation at the NPP, on the works completed and on measures to improve safety of the reactors. Then, he proceeded to the issue of resettlement to Slavutich: "In this year we should abandon the rotational work arrangements and occupy 150 thousand square metres of housing in Slavutich. Besides, we have to complete the NPP staff by skilled personnel to replace experienced workers who are quitting. We conducted individual conversations with all personnel members on matters of resettlement to Slavutich. From the overall figure of 4335 staff members of the Chernobyl NPP, 1901 persons will resettle to Slavutich and leave their housing in different cities of the USSR. Documents of the CPSU Central Committee and the USSR Council of Ministers were of much support for us in this respect. The number of people who will resettle, increased by 600 persons. From the operational personnel, 534 persons will resettle and 481 will not. 50% of the Chernobyl NPP communists will not resettle".

Scherbina B.E. "The latter figure characterises the party organisation of the Chernobyl NPP with absolute clarity. Are communists worth anything if they look for better places for themselves? Could the Party rely on such communists? We do not need wobbling, we need to act, and the number of hesitant ones will decrease immediately. Have you already fired anyone on these grounds?"

Umanets M.P. "We cannot do it while we do not have a personnel reserve. We fire only slackers and drinkers".

Lukonin N.F. "You may start from repair workers. There are many of them. Twenty or thirty of them may be fired without hesitation. Do not fire operational personnel so far, if they cannot be replaced, but do fire repair workers".

Scherbina B.E. "It is necessary to act more decisively. The key issue is associated now with recruiting new personnel. But you should not protract the process. You should not play games with people. It might just aggravate the situation, and nobody knows, what schizophrenic acts might emerge. It is necessary to act resolutely, relying on a position of principle".

23.02.1988. The operational briefing of the Chernobyl NPP Director

Umanets M.P. "The situation with personnel is pretty bad. Other NPPs do not provide us good specialists. Having 500 vacant jobs we managed to hire only 69 people, moreover, we were not able to hire the ones we needed. They provide us a human ballast, people who are not needed. The Minister's Order is of no use for us, and we will be made eventually responsible for the situation. Therefore, you must arrange presence of our recruiters at every NPP, they must be present there permanently!

I am particularly concerned about behaviour of our personnel, they are more focused on their torn between Kiev and Slavutich instead of focusing on their work. Shift personnel started to play backgammon and dominoes. People sleep at their workplaces, including chief shift managers. It is necessary to schedule surprise inspections and personnel checks by unit managers".

26.02.1988. The party meeting of communists of the Chernobyl NPP

The meeting's presidium: Lukyanenko, Borodavko, Revenko, Litvinov, Umanets, Parashin, Berezin, Zemskov, Ezhov, Grishaev, Karyaka.

Borodavko E.A.: On tasks of the Chernobyl NPP Party organisation in the course of implementation of the Decree of the CPSU Central Committee and the USSR Council of Ministers on results of the accident mitigation works.

In order to abandon the rotational work arrangements we need 4335 persons. Now we have 2.5 thousand of the old personnel (600 of them will resettle) and 2.3 thousand new workers (1300 of them will resettle). In professional terms they are not equal. From the overall number of communists of the Chernobyl NPP, 340 persons agreed to resettle to Slavutich …

What should we do with the ones who will not be able to resettle? We will rely on the Decree of the CPSU Central Committee and the USSR Council of Ministers and will communicate with everyone of them individually.

Afanasiev N.V. (the chief engineer of TICS) "The Administration and the Party Committee should be blamed - they set themselves opposed to the collective. They enticed people to Kiev to engage them into the accident mitigation works. They made a lot of lucrative promises but failed to keep them. They got an unsatisfactory assessment for that. The Party Committee Secretary Borodavko is wrong, the problem cannot be solved by force.

Why we object to the resettlement - doctors tell us that healthy children will not suffer. But our children have already got 15 to 20 rem. We do not know how food will be supplied to the town, maybe from nearby fields. We do not know how we will go to work. People fear that the Administration and the Party Committee will continue to press them.

We propose: to categorise the personnel (former Pripyat residents, pensioners, residents of other cities with permanent residence registration there). We need temporary labour contracts. The questioning of engineers of our section revealed that 15% of staff members will resettle on the current conditions and 60% of them will resettle provided their Kiev flats will be reserved.

I will resettle to Slavutich but I cannot guarantee safe operations of my new subordinates".

Zakharov V.G. "we many times discussed the problems mentioned by N.V. Afanasyev. The Administration of the Chernobyl NPP, including myself could say much more. (Noisy reaction of the meeting participants, interruptions, a clear antagonism between the personnel and the Administration).

Revenko G.I. "I want to say from the start that nobody will ever force anyone to resettle to Slavutich. We should not get scattered for nothing. We will not allow forced resettlement, our promise to make Slavutich a place of permanent residence remains in force".

Yakoveko Yu. V. (the Water Section) "We all are in a difficult situation, including the Administration, the Party Committee, the Trade Union Committee and Pripyat residents alike. I want to return to the beginning, when we were evacuated from Pripyat on 27.04.86. At that time, Grigoriy Ivanovich Revenko told us than we will live in a town of our own. And now we have the town. We make tours there for residents of other cities, they choose flats there for themselves. But when the time of the former Pripyat residents comes, they find that they have no chances to get the flats. Four high managers distribute something allocated by Zakharov to the section, that is democracy as he calls it. I propose to give Pripyat residents what they want. There are too many of them. The ones who do not want to resettle will fall away themselves, they will not endure. Let the Director control distribution of the flats.

Slavutich is a good town, it will be like Pripyat later, naturally, we will have some initial difficulties. But who can say something about the forest there, is it safe for walking? Maybe it is safe, but nobody says anything. I want to say about young operators - they work from 1984, and since 1987 they several times approached Verla - the shift manager of the Section - for his authorisation to rise their skill category. He ignored them altogether. Such chiefs should be fired. The Director should control such matters. It is necessary to allow pensioners to work their terms out".

Lavrichenko I.K. (RSS[10]) "Nobody has emphasised the key point - why people do not want to resettle to Slavutich, they do not want due to poor labour conditions. We have too much manual labour. We work at the level of 1930s, as the Director said. We are not mammoths, we could not bear such a load of 5 - 6 rem/year (0.05 - 0.06 Gy/year) for a long time... But in the Trade Union Committee they told me that the problems of labour conditions is not a general issue, for them general issues are limited to distribution of cars, can lids and such like.

There are many violators in CRS and their numbers will not decrease even if you organise 25 commissions. People drink for different reasons. I will not specify them. What sort of commissions do we have if they cannot address the causes?

I would recommend the Director to retain old workers. And one more thing, a comrade who addressed the meeting said that we have no time to think. But we have the time, thinking is never too late. People do not trust anybody, they do not trust the Public Health Ministry, the Trade Union Committee, the Director and me alike... Care of people, do not kill them in the course of repair works. Otherwise, a half of them will beetle off".

Navalikhin V.M. (the laboratory of non-destructive testing) "I will tell you, why I will resettle to Slavutich. We had decided that with my wife so early as in late 1986. As for health of our children, my wife said that she trusted me, she was sure that I would not expose the children to a mortal danger. In Slavutich, everything will be better that in Kiev".

Revenko G.I. (the First Secretary of the oblast-level Party Committee) "Nobody ordered me to come here, I came on my own initiative. I listen to the meeting's exchanges with pleasure and I think that the participants are not very battlesome. The first thing I see is that the Administration, the Party Committee, the Trade Union Committee and the Young Communist League slowly recast their work. It is necessary to listen to people, to address their problems and to move forward.

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[10] *The Radiation Safety NPP Section*

Your former colleagues send letters to us from different locations, asking for return. People want to return from Alma-Ata, Leningrad and other cities.

However, there are some people of a troublemaking sort now. In the course of a meeting in Kiev, one such man asked me the same question three times and I answered the question three times. Later on, some people had moved him out - I am grateful to them.

Top officials have to communicate with ordinary people informally. That is the reason of their grievances.

I do not want to rend the air with empty pathetic words, we just need to sit and identify who is for what, we just need to start working calmly. We do not need to force anybody.

It is necessary to treat former Pripyat residents separately. They should be provided at least 13.65 square metres of living space per person. We cannot stick to formalities in these matters, a pair of metres more or less do not matter much. Let the collective decide. Would you decide to provide a single-room flat with windows to the North to Umanets? The decision is yours. But I know that you would not decide in such a way.

The personnel discipline is the key issue now. One may accept equipment malfunctions. But when a human error results in an accident, it suggests laxity and liberalism. The oblast Party Committee will not tolerate such things. The issue of higher priority of state interests over the individual ones is not a minor issue, it is the issue of major importance...

So far, Slavutich is not a town of the year 2000. But we will be able to make it such a town if we want, even with application of old designs. If you do not like the housing provided, you can reject it. Am I correct, Mikhail Panteleevich?

The Party work is seriously neglected, one should try a lot to get such results! I like your meeting, but your sharpness looks somehow doltish. If people do not trust propagandists, whom do you expect to believe in your propaganda? Why do you stick to a dual standards policy? Behave like Communists! If we will not enhance the Party work we will not be able to ensure secure operation of the NPP.

Now, I will answer the questions:

1. We do not have access to documents of the Central Committee and the Council of Ministers. Why?

- I will ask for authorisation to make the Chernobyl NPP personnel informed on the documents.

2. I have to work for three years to reach the pension age. But they do not provide me a hostel accommodation in Slavutich. What should I do?

- I am a CPSU member and I comply with decisions of the Party. I advise you to follow suit.

3. If workers will quit the Chernobyl NPP, will they lose their flats in Kiev?

- No. You will got residence registration, but only after resettlement to Slavutich. That is the only option.

4. Concerning assistance for those who will stay in Kiev.

Staff reduction measures are expected to affect 40 - 50% of persons employed in bodies and organisations of Moscow, Kiev, etc. What should be do with them - ranging from ministers to typewriters? We will have hard times, I have to admit.

Maksimuk P.M. (CRS) "We have too little information and too late. The Party Committee lagged behind the events. I refused to resettle to Slavutich, notwithstanding that I want to and my wife also wants. But we have to think about our children. Doctors recommend our children to have rest in Yalta and Miskhore, but they had their vacations in Donetskaya oblast. The NPP Administration and the Party Committee set themselves opposed to the collective by their multiple false promises".

Umanets M.P. "First of all, I want to assure you that I am completely aware of my responsibility for the NPP safety. I made my main conclusion on the accident - it cannot be allowed to happen again.

Accounting for the contemporary situation, neither I myself, nor the Party Committee can guarantee safety of the NPP. Only 340 communists from the overall figure of 823 communists of our Party organisation will resettle to Slavutich. Only 20% of the core personnel will resettle, and a lot of things depend on them. Now, patriotism has already ceased to motivate people, as we started to operate in normal conditions. We can hardly attract anyone by career opportunities or by the weather. But we do have other specifics, such as 3 hours long travel to work. Should the ratio of resettlers remain the same, we would not be able to guarantee safety of the NPP. Many people consider my position as hard. Yes, I cannot understand a communist who told us that he will not resettle to Slavutich because a musical school is not available there. I cannot understand a communist who cannot persuade his wife - a real communist must explain her that he values his Party Card higher!

I can understand the ones who have ill children demanding medical treatment that is available in Kiev only. But we will provide medical treatment to children with general health problems in Slavutich, we will provide treatment to all there. We invested 25 million roubles into the polyclinic facility there.

Cover-up is flourishing at our NPP, and communists fail to penetrate it. Five workers appear drunk, the guards and medical staff do not admit them to work, but their superiors come and take them to work. I will force these managers to clean streets for three months jointly with the violators!

The chief NPP shift manager, communist Fazly, arranged night sleep to the RSS shift manager and the whole shift personnel. But later on, 8 false witnesses emerged who claimed that no sleep was provided!

As for the repair works - the quality of repair works deteriorated substantially, particularly in CRS and TICS. In 20 days, while working in transitional modes we encountered four SDS-5 events (emergency reactor shut-down - N.K.) and one turbine halt. We have not ever had such a situation. It is necessary to improve the situation without delay. I am sure that the accident of April 26 will never happen again. But accidents may happen. And all of you know what is an accident at the Chernobyl NPP. A minor ignition at Unit 4 resulted in the situation when I had to provide explanations to the deputy Chairman of the USSR Council of Ministers, to the Central Committee and the oblast Party Committee. Scherbina personally ordered me to fire the unit chief manager of RS-4. But he felt responsibility only when I told him about these developments...

I leave the rostrum, being fully convinced that the number of resettles to Slavutich will increase due to efforts of the Party organisation".

Borodavko E.A. "I will answer the questions on pay for the kindergarten. But first of all I would like to thank all the communists for their comments. I propose to sum-up the meeting".

The deputy NPP RS chief Anatoliy Kedrov read the draft resolution of the Party meeting. The meeting decided:

1. Take the Decree of the CPSU Central Committee as a guideline.
2. To transfer to the non-rotational labour arrangements.
3. To work individually with every particular worker in units, particularly with the ones who follow double standards.
4. To start resettlement to Slavutich this March. To oblige unit managers and communists to resettle in March - April.
5. The Administration and the Party Committee should replace managers, who do not resettle to Slavutich.

- To train good replacements for the ones who do not resettle.
- To examine validity of explanations provided by managers and communists who refuse to resettle to Slavutich.
- To discuss communists who refuse to resettle and reasons of their refusals at Party meetings in sections' party organisations.
- To establish procedures for cancellation of labour contracts, accounting for labour contribution of every individual worker. Communists who refuse the resettlement, should be considered as opponents of the CPSU Central Committee and the USSR Council of Ministers.

- To organises excursions to Slavutich and a direct line of communication with the Director.
6. To establish the Council of the NPP labour collective.
7. To explore the opportunity of establishment of a Council of Veterans.
8. To provide all the information to the collective.
9. To authorise the Director, unit-level Party secretaries, and chiefs of NPP sections to supervise implementation of the meeting's decision.

Karyaka G.A. (a member of the Chernobyl NPP Party Committee) "Who is voting for approval of the decision in general terms? Unanimous vote. Are there any comments or proposals?"

Afanasyev N.V. "Labour collectives should be empowered to elect their new managers themselves, to replace the ones who do not resettle to Slavutich". (The participants express their approval).

Revenko G.I. "I think that we should not separate the former Pripyat residents and the newly admitted ones in terms of their responsibility. All people should be treated equally, but on an individual basis".

10.03.1988. The party meeting of communists of the Chernobyl NPP

(The meeting was attended by the Second Secretary of the oblast Party Committee Malomuzh V.G., Piruev A.V. from the Ministry of Nuclear Power Industry, the Secretary of Pripyat City Party Committee Lukyanenko V.G.).

The NPP Party Secretary Borodavko E.A. opened the meeting by his speech on operational failures at the NPP and the delayed relaunch of Unit 3. Then he addressed discipline-related issues: "To tighten control… To deter violations… In this year we already registered 8 cases of alcohol-related truancies…"

So far, they allocated 1100 flats to us in Slavutich. To switch to the non-rotation work mode we need to have 4335 people, but now we have 4837. From the latter figure, only 2500 people represent the old NPP personnel. Only 2023 persons agreed to resettle to Slavutich. Where should we find the rest? Only 80 workers from other NPPs agreed to resettle to Slavutich.

In 1987, 8000 persons applied to out Personnel Department and we admitted 2292 persons. But the new workforce includes many come-and-go people, therefore, we have to retain the old personnel. From the overall figure of 823 CPSU members only 340 persons agreed to resettle. The rest of them refer to different reasons: 73 persons claimed health problems, 257 persons referred to family matters while the others are of pension age. Individual interviews with them suggest that people require fixed-term labour contracts and opportunities to reserve their flats in Kiev. Some have personal grievances, some were not provided benefits and awards.

From the security point of view, we cannot accept demands of the ones who refuse to resettle, as we need to arrange a stable core team of the NPP personnel from the start…

We have to approve a decision that communists who refuse to resettle, fail to play their leading role in establishment of the stable core team of the NPP personnel and in ensuring safety of the NPP...

What will happen to those who refuse to resettle? We will apply a strictly tailored approach, but in line with the decision we are to approve today".

Then, communists from NPP sections addressed the meeting.

Kindzitskiy (a machinist, TS-2) "The main fault is associated with the fact that the Party organisation is expected to work for the collective. Now, they have lost confidence of the collective. Party decisions lack effectiveness, they lack openness...

The Party Committee has poor relations with the trade union. The trade union practically does not exist, like the Young Communist League. No technical training is provided. The council of young specialists does not work. It is necessary to demonstrate results of the work, but are there any top managers or members of the Party Committee who were sanctioned for their failures to work? …

I assess the work of the Party Committee in 1987 as unsatisfactory".

Belava V.M. (a senior master, ES) "Do we meet here to decide anything or just to blow off steam? I am surprised by optimism of our people! We already had too many empty talks. Why does the Politbureau decide who should go and where to, why cannot we decide these matters themselves? We unanimously approved actions of Stalin, Khrustchev and Brezhnev earlier and where are we now?! Let us start to think and decide, instead of mere approving.

In May 1986, Boris Scherbina said that the maximal contamination level at the NPP site does not exceed 10 - 15 mR/hour (0.10 - 0.12 m Sv/hour), and the level was already reduced in 2 to 3 times. Does it mean that Antoshkin and Samoilenko were awarded titles of Heroes for 2 - 3 mR (0.02 - 0.03 mGy)?...

Many old workers do not want to resettle to Slavutich. Their reasons are well known. I think, it is necessary to meet people's wishes. The optimal ratio should be set as 80% of old workers to 20% of new ones, not the opposite…

Let us think before doing. People should be provided opportunities to participate in decision-making, and they would engage actively. Labour contracts should be arranged, particularly in the case of new workers, for a one year term maximum. A good worker would know for sure that he will be retained. Let us listen attentively to words of writer Yuriy Scherbak: "If our voices will not be heard, if yes-men will succeed in their career growth, if thoughtless obedience will be considered as the highest virtue, this will mean that the Chernobyl has not teach us anything". (Applause of the whole audience).

Annenkov N.I. (CS) "... There are rumours, that the Director an the Chief Engineer will be promoted elsewhere after completion of the resettlement to Slavutich, while the newly appointed chiefs will nor be aware of the past developments. There were many empty promises of different high officials. They undermined our trust. On behalf of the section collective I propose to provide at least hostel accommodations for old workers instead of firing them. In such a case, they will be able to train new specialists adequately".

Sabiryanov B.R. (RSS) "I attended the previous Party meeting, when the oblast Party Committee Secretary Revenko promised to familiarise us with the Decree of the CPSU Central Committee - the one all refer to. But we still are not familiarised with the Decree. The oblast Party Committee has the Decree, the document deals with us but we still are not aware...

As for the housing reservation - Kola and Bilibin NPPs are not in the accident-affected list, but all their personnel have their housing reserved. It is necessary to allow us to reserve housing as well, in order to ensure reliable personnel". (Applause).

Bogomaz A.F. (The Experimental Silicon Radiation Doping Section) "The Party's aim is clear, but are the correct ways used to accomplish it? The contemporary situation resembles the collectivisation of 1930s, when people were forced to join collective farms. What do we have as a result? The agriculture still cannot recover from the blow!

Today, they threaten to fire us or to expel from the Party. Is it a modern approach? Planned propaganda actions in sections were fully accomplished, but they failed to produce any results. Now, top officials must approach the people and listen to their proposals...".

Lukyanenko V.G. (the Secretary of Pripyat city Party Committee) "The key aim now is associated with ensuring safe operation of the NPP and a stable collective. The Chernobyl NPP Party Committee failed to pay a due attention to work in sections, focusing on external issues mainly. Party bureaus in sections failed to play leading roles in their collectives. Now we need to stick to a position of principle. After individual interviews with communists, rumours emerged at the NPP that they might lose their Party cards. But if a communist quits and does not ensure a workplace replacement, is not he a deserter? We already need a program for transition to standard remuneration arrangements in 1991. We need to prepare to election of managers by labour collectives.

Some problems will be encountered in Slavutich. Any new business is always prone to difficulties... Let us work!"

Novikov S.V. (TICS) "I am resettling to Slavutich, but I still have a lot of concerns. Safety of the Chernobyl NPP is the key concern… To operate under non-rotational arrangements we will need 563 people, but only 178 workers will resettle to Slavutich. There are only 60 old NPP staff members among them or 7%. What a sort of reliability and safety could they ensure?

I want to note, that workers distrust the Administration and highest authorities pathologically. They hide texts of Decrees from us. People should be familiarised with the source documents.

If a man signs a labour contract for 3 years, this does not mean that he is a temporary worker. People simply are not sure about their social protection in the future. But if they have good living conditions, they will extend contracts for 3 other years or indefinitely… It is the time to abandon persuading us by words, try to persuade us by your deeds!"

Piruev V.A. "The speakers did not say a lot about the NPP developments that concern the Politbureau and the Government.

As for the "steam blowing"... whether it is necessary to blow it off. M.S. Gorbachev already said that perestroika does not proceed in the way we need it. Some people tend to remain silent. Some people seem to agree with perestroika, but there are some saboteurs as well. Some tend to blame all and everything. We need to assess themselves, to assess our roles in ensuring safety, as violations demonstrate a threatening dynamics.

You worked well in 1987. But in 1988, we have to work three times better! It is necessary to organise basic economic and legal training at the NPP to operate in a competent manner.

As for Slavutich - the Ministry of Public Health approved the resettlement and signed all documents. (A question from the audience - Who has seen them?).

As for the complains. We receive complains from all, including old and new personnel members alike. I would not even call them complains, as they contain proposals, refer to everyday issues. All people have questions…

As for your delegation to the CPSU Central Committee on the matter of allegedly concealed benefits. There are agencies that set procedures for application of labour collectives to governing bodies. You should trust these bodies. You are informed on all matters you are entitled to know, without any alterations…".

Borisevich Ya.A. (RS-1) “Equipment in the reactor section is outdated, it is difficult to work there. That is what we should think of… No visual aid are available in the central room for training of new staff members. We do not have cross-cutting drawings of technological channels, good drawings of the fuel loading machine are lacking.

No reliable radiation load information is available for Slavutich. We need a map of its radioactive contamination, to be accessible to everyone...

Our days consist of 8 hours at work, 5 hours of travel to work and 8 hours of sleep. What time do we have for our families, culture and exercise?”

Umanets M.P. “I ask for 17 minutes. I will reply to the written questions. They propose the Director, the Chief Engineer, Sorokin, Spektor and V. Scherbina to work for 5 years at the Chernobyl NPP, arguing that such a measure would allow to form a stable core collective (laugh in the audience). I reply - yes, I promised to work at the Chernobyl NPP for 5 years to the CPSU Central Committee. I warned on the matter those persons whom I hired personally …

I accept your critical comments with respect, but I assess these comments in terms of safety. Labour and technological discipline at the Chernobyl NPP declined very seriously. Drinking is rampant... What can you say about sleeping at workplaces, or about playing games?

Only 10% of the equipment items after repairs are acceptable! Such is the work of the collective that was able to do everything earlier!

What is the solution? I see the solution in seeing tomorrow 800 communists who will submit their applications for resettlement to Slavutich… It is a difficult question, the question on what is of higher priority - personal interests or the public ones?

Some claim that our proposals were not heard. This is not the case. I told about them at all levels, I told about them to Revenko, Scherbitskiy and Dolgikh. We were listened to with the most benevolent attention and they provided their arguments at the level of the oblast, the republic and the country. Now it is our turn, the NPP collective should follow the principle of democratic centralism”.

Malomuzh V.G. “Your condonation and complacence cannot be tolerated!... Discipline declined… Safety declined… The punishment is unavoidable!… We watch closely almost everyone, everything that is being made in connection with resettlement to Slavutich… Nobody will resettle you to Slavutich by force! We will rely on persuasion on a strictly individualised basis. It is necessary to establish groups of the NPP top managers and representatives of the Ministry of Nuclear Power Industry to work with every NPP worker persuading him to make the only correct choice… You must make the personnel convinced that objectives of the Central Committee’s Decree will be certainly met!”

A note was handed to Malomuzh from the audience: “Is it true, that on April 26, 1986, you blocked departure of people from Pripyat? That is suggested by testimony of Vladimir Pavlovich Voloshko, the Chairman of Pripyat city Executive Committee”.

Malomuzh V.G. “I did not issue such guidance. I do not know what Voloshko said”.

Then, the Party meeting participants voted for the same text of resolution, that was approved at the previous meeting.

As an example of individual “persuasion” of personnel referred to by the Party Secretary Malomuzh, I can tell about my own case. I went through a range of talks conducted to force me to resettle to Slavutich. The last one in the range was a conversation with Yu.N. Filimontsev, the Chief of the Directorate General of NPP Operation of the USSR Ministry of Nuclear Power Industry. Yuriy Nikovaevich was “straight and rough” like a character of a popular song of V. Vysotskiy. He asked me “Karpan, why do not you go?”

“I do not want to expose my family to the dirty place”.

Filimontsev insisted “What do you expect? You will have no chances, we will pull the plug on you in the whole industry, no NPP will employ you!”

“No problems. I have been intending to quit the nuclear power industry for a long time”.

Filimontsev did not believe me “Really? Let us launch Unit 3 first and leave fantasies for tomorrow”.

However, it was not a fantasy, it was a well considered decision. For the first time, I made it public at the parting event of E.N. Pozdyshev, who was transferred to Moscow in connection with his promotion to the Chief of one of Directorates General of the Ministry of Nuclear Power Industry. He told me that after relaunch of Chernobyl Unit 3 he would seek to arrange my transfer to another NPP as a Chief Engineer of an operational NPP or one under construction. I refused and explained why - I realised that adverse effects of nuclear power industry overweight its benefits. And I really left the nuclear power industry, immediately after recommissioning of Unit 3 of the Chernobyl NPP.

19.03.1988. The operational briefing of the Chernobyl NPP Director

Umanets M.P. “It is the time to complete resettlement to Slavutich. The Chairman of the Governmental Commission Scherbina and the Chief of the CPSU Central Committee Sector Maryin ordered us to switch to the non-rotational work arrangements in the third quarter of this year. If necessary, they would stop two units of the NPP to allow us to complete training of the new personnel.

The rotation will not continue! They decided to cover costs of the resettlement to Slavutich and repairs of Kiev flats (prior to their transfer to municipal housing authorities) at the expense of the accident mitigation works".

The afterword to the Chapter:

- top managers of the Chernobyl NPP were sanctioned by issuance of serious Party reprimands for their failure to ensure the resettlement to Slavutich. The NPP Party Secretary Borodavko E.A. was expelled from the Party on 26.09.1988.
- only 450 workers of the responsible and professional pre-accident NPP personnel had resettled to Slavutich (or 10%).
- on October 11, 1991, a fire affected turbine generator # 4 of NPP reactor Unit 2. 180 tons of turbine oil burned off, the roof of the turbine room building was seriously damaged (about 2.5 thousand square metres of the roof plates collapsed). Unit 2 had to be shut down finally.
- on November 30, 1996, Unit 1 was shut down finally.
- in 2000, the last operational reactor unit of the NPP (Unit 3) was decommissioned. Now, 3.5 thousand people work at the idle NPP site. The town, that existed for the sole purpose of serving the NPP turned into a trap for young people.
- for 10 years, the state budget has been allocating $50 million per annum for maintenance of the NPP and the town, and nobody has any idea when the funding might cease.

The former NPP Director Umanets M.P. now assesses the events of that time as follows:

("Delo" Newspaper, 2006)

Lyudmila Polyakh (correspondent) - "Are you aware of the fate of the NPP personnel, engaged into the accident mitigation works in 1987 - 1988?"

Mikhail Umanets - "It is a terrible story. These people were offended and set aside. The personnel shut down operational reactor units and ensured their safe maintenance. In early May almost all of them were evacuated from the NPP site, but in late May they were called back. By that time, 27 their comrades were already buried at Mitinskiy cemetery in Moscow. They were provided flats in Kiev. However, in parallel, the town of Slavutich was being constructed. And the state thrown these people to a dilemma - you may retain your jobs only if you return your flats in Kiev in exchange for flats in Slavutich. From the overall figure of 5 thousands-strong personnel, only 500 persons decided to continue to work at the NPP. But those who opted to quit, made another great accomplishment. When it became clear that they would quit the NPP, we mobilised 4.5 thousand specialists from the whole USSR. And only the personnel who were ousted by the state from the NPP, were able to train the new workforce. Later on, I have never heard any complains from the newly admitted personnel, that ‘their trainers trained them poorly’.”

Information note

Before the accident, the Chernobyl NPP officially employed 6506 persons (including workers of social facilities of the NPP in Pripyat). The above figure included 4400 persons of industrial staff. The operational personnel (1300 persons) included 250 operational workers for Unit 5.

Chapter 2. The tragedy transforms into a farce

How the explosion of RBMK reactor was prepared

I will prove a few key historical facts of the RBMK type nuclear reactor (from the launch of design works to the accident). By the moment of its approval, the Engineering Design of RBMK-1000 NPP Unit was plagued by dozens of deviations from the due mandatory safety standards in force from 1973 - 74. The key safety standards included "General Provisions of Ensuring Safety of Nuclear Power Plants in the Course of their Design, Construction and Operation" (GSP-73) and "Nuclear Safety Rules for Nuclear Power Plants" (NSR-04-74). In 1982, after approval of "General Safety Provisions" (GSP-82), RBMK design also was not made compliant with the new requirements (a grave violation).

A scandal was about to happen in the reactor designers community, that incorporated representatives of different design schools. NPP personnel in charge of reactor safety matters were close to launching a revolt. Many letters with critical comments on the reactor were submitted to the reactor developers and the State Nuclear Supervision Authority. It was impossible to operate RBMK type reactors any longer, as they demonstrated a range of dangerous features in the course of their practical introduction. The reactors should be urgently put out of operation and modernised to eliminate design flaws. However, such an option endangered the plan of electric power generation in the USSR, entailing all associated consequences for those in charge. Therefore, in 1984, the Chief Designer (NIKIET) and the Scientific Supervisor (Kurchatov Institute of Atomic Energy), urgently initiated a session of the Inter-agency R&D Council on the Nuclear Power Industry. The Council approved an unprecedented decision - to "legalise" temporarily the deviations from the due safety rules, and to postpone reactor modernisation works for several years - up to the already scheduled reactor reconstruction works [*see "The Chernobyl Disaster: Causes and Consequences (The Expert Conclusions)", Part 1, Minsk, 1993, pages 57 - 58*]. Using such a simple bureaucratic trick, the designers managed to shuffle off their responsibility to the Inter-agency Council, that allowed to continue operation of 15 high capacity reactor units that failed to meet nuclear safety requirements in a fatally serious way.

NPP specialists were not satisfied by the decision of the Inter-agency Council - they continued to disclose flaws of the reactor and demanded the Chief Designer and the Scientific Supervisor to take specific measures to improve nuclear safety of NPP reactor units. The last security assessment (before the accident) was an unprecedented review of nuclear safety of RBMK reactor, conducted by the Nuclear Safety Inspector of Kursk NPP Yadrikhinskiy A.A., who identified thirty two grave deviations in the reactor and its safety systems design from NSR-04-74, GSP-82, Rules of Design and Safe Operation of NPPs [see "The Chernobyl Tragedy. Documents and Materials". The Institute of Ukrainian History. Kiev, Naukova Dumka. 1996, pages 58 - 71].

He submitted his results (in five months before the Chernobyl Disaster!) to Moscow - to the Chief of 1st Directorate General of the State Nuclear Supervision Authority of the USSR Gorelikhin V.K. and to Volgodonsk - to the Chief of the Southern District Directorate of the State Nuclear Supervision Authority Shkabara V.S.

Moscow ignored demands of A.A. Yadrikhinskiy (as usual), but he received an official response from Volgodonsk. Letter of the State Nuclear Supervision Service of 06.12.85 (# YuO 32-829) contained remarkable words of the Chief of the District Directorate:

"... according to clause 11.5. of the Conclusions ***the author proposes to halt all RBMK type reactors … due to physical deficiencies of the reactor control and safety system*** *(CSS), while, as I think, the composition of fuel rods and adsorber rods, referred to in the above column, meets requirements of NSR".*

It was a response according to principle "when I want your opinion, I will rattle your cage". Naturally, Shkabara was not the man who took the sole responsibility for a failure to take urgent measures, that could have prevented the Chernobyl accident. He was just the last link in a chain of scientific bureaucrats of different calibres, whose lack of professionalism and responsibility was covered by his name.

Notwithstanding the inspector's demand to halt the reactors, substantiated by his rigorous calculations and references to the Safety Rules, nuclear power plants with RBMK reactors continued to operate up to April 26, 1986, when the Chernobyl NPP was shattered by a catastrophic accident that could have been avoided.

The pre-trial expert assessment of causes of the accident

Many representatives of the community of nuclear specialists assumed that an accident with reactor runaway at prompt neutrons in the case of Soviet reactors is impossible, as such a course of events is prevented by reactor design and physical parameters. They assumed that a positive reactivity necessary to generate runaway of a power-generating reactor cannot emerge quicker than the response rate of its emergency shut-down systems. Designers of reactor control and safety systems persuaded all that the safety system will introduce negative reactivity swiftly and shut down the reactor. Actually, RBMK type reactors had unacceptably long time of insertion of SDS rods into the active core - 12 sec instead of 2 sec that are generally considered safe.

The most serious accident (as developers thought) with a power-generating reactor was assumed to be associated with loss of coolant in the active core with subsequent depressurising of fuel assemblies due to heat generation. The problem was associated with the fact that even in the course of a normal reactor shutdown, residual heat continues to release in the fuel rods (due to decay of accumulated uranium fission products). In order to prevent such accidents, all nuclear reactors are equipped by emergency cooling systems and other safety precautions. However, if these systems are disabled (a grave violation of reactor operation rules), the above accident becomes fairly possible. Such a logic was initially followed in the course of investigation of causes of the Chernobyl accident, launched by the Governmental Commission on April 27, 1986 (by the group of the deputy Minister of Medium Machine-building Industry A.G. Meshkov). Meshkov assumed a rather simple course of the accident - cavitation damaged pipelines of pressure section of MFCC, and caused a MCA, while the emergency cooling system was switched off by the NPP personnel. The reactor was left without water inflow, that resulted in its high positive reactivity due to the full void reactivity effect. The above version of the course of the accident was considered as the most probable one. However, at that time, the Commission did not have all the necessary data.

By that time, magnetic records of DREG program and the rundown oscillograph records were not processed yet. Nonetheless, they swiftly produced the Accident Investigation Report that blamed the NPP personnel only (The Investigation Report on Causes of the Accident at Unit 4 of the Chernobyl NPP on 26.04.86" ChNPP, reg. # 79, pu 05.05.86.). The Report was signed by all members of A.G. Meshkov's commission except the deputy Minister of Power Industry G.A. Shasharin and the Director of VNIIAES A.A. Abagyan. They had reasons to refuse signing the Report, as in parallel with the investigation of the Governmental Commission, specialists of the Ministry of Power Industry and VNIIAES conducted their own investigation in Moscow, that allowed to identify two important facts:

1) In the state of the reactor by the moment of its shutdown by CRCE Toptunov, insertion of the safety rods into the active core introduced some positive reactivity at the initial stage of their insertion.

2) Results of processing of the rundown oscillograph records synchronised with records of in-house instruments of the Unit Control Room demonstrated that the automatic shutdown button was activated

by Leonid Toptunov before the accident (not after it as the Meshkov's Commission Report suggested). It was the most decisive findings that limited the investigation to two potential options. First - the reactor runaway process had already started when operators identified it and decided to halt by SDS-5 button, but it was too late. Second - the operators started to shut down the reactor in connection with completion of the test program and then (as a result of these actions) the accident started. At the same time it became clear that the introduction of positive reactivity by the emergency shut-down system could only launch the runaway process (due to its magnitude that does not exceed the delayed neutron fraction of 1 â). To make the accident really disastrous, another positive reactivity source was needed to intervene after the SDS displacers' effect. It was the void reactivity effect only that might play such a role - in the case of Unit 4 reactor its magnitude reached 5 â. Introduction of reactivity much higher than 1 â can result in a swift runaway power release in a nuclear reactor, like in the case of a nuclear bomb. Such a runaway may blow any reactor to pieces, nothing to say about RBMK type one, designed without a massive external containment of reinforced concrete.

Accounting for the above facts, instead of finalisation of the first Accident Investigation Report, produced by MMMI, the Ministry of Power Industry proposed a more substantiated version of the accident. In such a way, the Annex to the Accident Investigation Report of Meshkov's group was produced - and the Annex radically altered the initial conclusions ("Annex to the Investigation Report on Causes of the Accident at Unit 4 of the Chernobyl NPP on 26.04.86", the USSR Ministry of Power Industry, "Soyuzatomenergo", reg. # 4/611, 1986). The Annex ended the joint investigation of causes of the Chernobyl accident by MMI and the Ministry of Power Industry. Then, a classical inter-agency fighting started. As the main battlefield, two agencies used the R&D Council of MMMI, chaired by Academician A.P. Aleksandrov, the President of the USSR Academy of Sciences and - as his second job - the Director of the Atomic Energy Institute (the Scientific Supervisor of the RBMK reactor project). The Council was initially a sole venture of MMMI, but due to efforts of A.P. Aleksandrov, the Council was transformed into an inter-agency one (IA Council), and positioned itself as the highest R&D authority in the nuclear power industry.

Trying to rebut charges, that were introduced to the Accident Investigation Report by the Annex produced by the Ministry of Power Industry, the Council conducted two special sessions (on June 2 and June 17, 1986). In the course of these sessions, representatives of the Chief Designer and the Scientific Supervisor (the developers of RBMK reactor) used all available means to prevent discussion of faults in the design and physical parameters of Unit 4 reactor of the Chernobyl NPP.

However, their opponent - the deputy Minister of Nuclear Power Industry G.A. Shasharin did not give up. He submitted his personal letter to the General Secretary of the CPSU Central Committee M.S. Gorbachev, providing a brief outline of developments in the IA R&D Council (IAC) and complaining that MMMI tries to conceal real causes of the accident (see the draft letter below in the Annex to this Part). Then, the development of the final conclusions on causes of the accident moved to the highest level - to the Politbureau of the CPSU Central Committee. The Party chiefs assembled a large team of scientists (led by the same Kurchatov Institute) and demanded them to produce a scientific and engineering report on results of activities of the Governmental Commission. It was that bulky report, that - after its edition by the Industrial Department of the CPSU Central Committee - became the official information on the Chernobyl NPP accident for the international community [The Expert Report for IAEA on the Chernobyl Accident. "Atomic Energy" magazine , v. 61, issue 5, November 1986]. It was a "truth about the accident" for foreigners. The Expert Report cannot be considered as the conclusion on the investigation of the accident's causes, as it does not suggest a specific initial event of the accident (even as a range of different versions), it does not analyse actions of the NPP operational personnel (in terms of their impacts on triggering and evolution of the initial event) and does not consider design and physical parameters of the reactor that caused the accident (or facilitated it). Instead, the Report provides a detailed account of difficulties of mathmodeling of the accident process and lists actual and supposed failures of the NPP personnel to meet the reactor's Operational Regulations.

The second "truth about the accident" was presented by the Chairman of the Governmental Commission at the session of the Politbureau of the CPSU Central Committee on July 3, 1986. The information was intended for the highest USSR leaders only. Below, I quote some extracts from the Minutes of the session (*the author expresses his sincere gratitude to Alla Yaroshinskaya, a Peoples Deputy of the USSR Supreme Council, who saved the document and to Vladimir Scherbina (Chernobyl NPP), who analysed conclusions of the Minutes, some of which I used below). See the full text of the Minutes in A.A. Yaroshinskaya's book - "The Nuclear Safety Philosophy", Moscow, 1996*).

Session of the Politbureau of the CPSU Central Committee
July 3, 1986.

"Top Secret"
The only copy (working records).

Chairman: comrade Gorbachev M.S. Participants: comrades Aliev G.A., Vorotnikov V.I., Gromyko A.A., Zaykov L.N., Ligachev E.K., Ryzhkov N.I., Solomentsev M.S., Scherbitskiy V.V., Demichev P.N., Dolgikh V.I., Slyunkov N.N., Sokolov S.L., Biryukova A.P., Dobrynin A.F., Nikonov V.P., Kapitonov I.V.

1. The Report of the Governmental Commission on investigation of causes of the accident at Chernobyl NPP on April 26, 1986.

Gorbachev: ... I give the floor to comrade Scherbina…

Scherbina B.E. (the deputy Chairman of the USSR Council of Ministers): ...the accident was caused by grave violations of the Technical Regulations by the operational personnel and in connection with serious flaws in the reactor design. However, these causes are not of equal significance. The Commission considers faults of the operational personnel as the initial event of the accident".

As we can see, he provides a familiar story again, notwithstanding that by that time the Governmental Commission was already well aware of very negative expert assessments of reliability of the reactor's design. However, later on, contradicting to his earlier words, the speaker said:

(Scherbina)... Assessing operational reliability of RBMK type reactors, the group of specialists, contracted by the Commission, made a conclusion that its parameters do not meet contemporary safety requirements. They concluded that in the case of an international expert assessment the reactor will be "ostracised". RBMK type reactors are potentially dangerous… All the people involved seem to be affected by heavily advertised presumably high safety of nuclear power plants... We should make a difficult decision on cancellation of construction of new nuclear power plants with RBMK type reactors... The Board of the Ministry of Power Industry and Electrification did not discuss issues associated with NPP safety since 1983.

... In 11th 5-years period, there were 1042 accidents with shutdown of NPP reactor units, including 381 accidents with RBMK type reactors..."

After the report of the Chairman of the Governmental Commission, the participants discussed reactor safety problems. The discussion highlighted unexpected and scarcely known secrets of Soviet reactor-building.

Gorbachev: Has the Commission ascertained why the under-developed reactor was introduced into industrial operation? In the USA, they rejected such reactors. Is it so, comrade Legasov?

Legasov: The USA did not develop and apply such reactors in power industry.

Gorbachev: The reactor was authorised for industrial application, but theoretical research was not continued... Why were not the theoretical research studies continued? Are not we in a situation when voluntarism of some individuals draws the country into a risky gamble?... Who proposed to locate NPPs nearby cities? Whose were these recommendations? ... By the way, the Americans did not launch construction of new NPPs after an accident there in 1979.

Scherbina: It was generally assumed that the problem of safety was solved. The publication of Kurchatov Institute claims so (the one drafted with participation of Legasov)...

Gorbachev: How many accidents did we have?

Bryukhanov (the Director of the Chernobyl NPP): About 1 - 2 accidents happen annually ... We did not know that something similar happened in 1975 at the Leningrad NPP.

Gorbachev: 104 accidents happened, who is responsible?

Meshkov: (the First deputy Minister of Medium Machine-building Industry of the USSR). The plant is not ours, it is of the Ministry of Power Industry.

Gorbachev: What could you say about RBMK type reactor?

Meshkov: The reactor is well tested. It lacks a containment only. It is safe if the Regulations are followed strictly.

Gorbachev: Why, then did you sign the documents stating that its production should be cancelled?... You surprise me. All people say that the reactor is underdeveloped, that its operation may cause risks, while you guard your corporate honour here.

Meshkov: I guard the honour of nuclear power industry...

Gorbachev: You continue to insist on things you told us for 30 year and that reflects the fact that the sphere of MMMI was outside scientific, state and Party control. And in the course of operations of the Governmental Commission, comrade Meshkov, I was informed that you behaved irresponsibly, tried to camouflage obvious facts…

Gorbachev: Sidorenko V.A. (the deputy Chairman of the USSR State Committee for Nuclear Power Industry Supervision) writes that RBMK reactors even after their reconstruction will not meet modern international requirements...

Shasharin G.A. (the deputy Minister of Power Industry and Electrification of the USSR): It is physics of the reactor that determined the scale of the accident. People had no idea that the reactor can get runaway in such a situation. We are not convinced that the modernisations would make it safe. It is possible to imagine dozens of situations that might produce the same results as in Chernobyl. This is particularly true for first reactor units of Leningrad, Kursk and Chernobyl NPPs. Ignalina NPP cannot be operated at its rated power level. These reactor units are not equipped by emergency cooling systems and should be put out of operation as a priority... We cannot build new RBMK reactors any more, I am absolutely sure. As for their modernisations, the costs will be never recovered. The philosophy of extension of NPPs service life is not always appropriate.

Gorbachev: What should Kurchatov Physics Institute do?

Aleksandrov: I think that the reactor property (runaway) may be eliminated. We have some considerations on potential options to address the problem. It might be done within a year or two.

Gorbachev: Does that concern the already operational reactors?

Aleksandrov: The currently operational reactors may be made safe. I will bet by old head that the reactors may be improved. I ask to relieve me from duties of the President of the Academy of Sciences and to give me opportunities to remediate my faults associated with deficiencies of the reactor.

Gorbachev: Is it possible to improve the reactors to the level of compliance with the international requirements?

Aleksandrov: ... All countries with developed nuclear power industry do not operate the type of reactors we apply".

Mayorets (the Minister of Nuclear Power Industry, a member of the Governmental Commission): As for RBMK type reactors, the question may be answered unequivocally. Nobody else in the World has opted to develop such a type of reactor... I insist that even after the upgrade RBMK type reactors would not comply to all our contemporary rules...

Ryzhkov: We headed to the accident. Should the accident fail to happen now, under the circumstances we have now it might happen anytime. Even that NPP was expected to explode twice, but they managed to do it only in the third year. As we know now, we had no year without accidents at NPPs... Design flaws of RBMK type reactor were also well known, but neither relevant ministries, nor the USSR Academy of Sciences made due conclusions... The Task Force believes that those NPPs with RBMK type reactors under construction that are close to completion should be completed while construction of further NPPs with these reactors should cease.

After the report of the Commission Chairman, the meeting participants discussed the problem of reliability of the reactor. Let us focus on key statements of the participants pertaining to causes of the accident:

1. The reactor has intrinsic inclination to "runway" due to flaws in the active core design (the President of the USSR Acad. Sci. Aleksandrov);
2. Operational reliability of the reactor does not meet modern safety requirements (the Chairman of the Governmental Commission Scherbina);

3. The course of the accident that resulted in destruction of the reactor was caused by design flaws of the reactor… The immediate direct cause of the initial reactivity increase was associated with water boiling in the active core... This initial reactivity growth was a manifestation of design deficiencies of the reactor, namely the positive void reactivity effect, that was determined by the active core structure (from conclusions of the Governmental Commission);
4. The initial reactivity growth was not supressed at the initial stage of insertion of safety rods after activation of the emergency reactor shutdown system. It was a manifestation of the second design flaw of the reactor - a poor design of the safety rods (from conclusions of the Governmental Commission);
5. Security of RBMK type reactors excessively relied on organisational and engineering arrangements, while the reactor's physics was not paid due attention (the Chairman of the State Committee for Nuclear Power Supervision Kulov);
6. The accident was caused by grave violations of the Technical Regulations by the operational personnel and in connection with serious flaws in the reactor design (Scherbina);
7. People did not know that the reactor might get runaway in such a situation (the deputy Minister Shasharin);
8. All the people involved seem to be affected by heavily advertised presumably high safety of nuclear power plants (Scherbina);
9. The accident was an inevitable result of general deficiencies in the state policy in the sphere of nuclear power industry management (the USSR Prime Minister Ryzhkov);
10. The underdeveloped reactor was transferred to the industry (Gorbachev);
11. Unsubstantiated termination of theoretical research on matters of the reactor safety after its transfer to the industry (Gorbachev);
12. Voluntarism of some individuals that has drawn the country into a risky gamble (Gorbachev);
13. The sphere of MMMI was outside scientific, state and Party control (Gorbachev);
14. RBMK type reactors are potentially dangerous (the Governmental Commission).

And now, let us list brief opinions expressed by the top officials of the USSR and the nuclear power industry at the session:

1. The head of state Gorbachev - The underdeveloped reactor was transferred to the industry.
2. The head of government Ryzhkov - We headed to the accident. Should the accident fail to happen now, under the circumstances we have now it might happen anytime.
3. The President of the USSR Acad. Sci. Aleksandrov - The reactor's inclination to runaway is a fault of the Scientific Supervisor and the Chief Designer of RBMK... I ask to relieve me from duties of the President of the Academy of Sciences and to give me opportunities to remediate my faults associated with deficiencies of the reactor.
4. The GAEN Chairman Kulov - The reactor's safety should be ensured by its physics instead of organisational and engineering measures.
5. The Minister of Power Industry Mayorets - Even after its upgrade RBMK type reactor would not meet all our requirements.
6. Shasharin, the deputy Minister of Power Industry, personally responsible for nuclear power industry - People had no idea that the reactor can get runaway in such a situation. It s possible to imagine dozens of situations that might produce the same results as in Chernobyl. This is particularly true for first reactor units of Leningrad, Kursk and Chernobyl NPPs.

The Politbureau meeting ranked causes of the Chernobyl NPP accident correctly:

1. The accident was a result of a premature termination of the reactor safety research, making RBMK "a potentially dangerous reactor". The responsibility for the failure rests primarily with the top officials of the state, the Academy of Sciences and the Ministry of Medium Machine-building Industry.
2. Physical parameters and the design of the reactor (including its control and safety systems) do not exclude the possibility of its "runaway" in particular situations in the course of its industrial operation. It amounted to a deviation from requirements of the Nuclear Safety Rules - inspector Yadrikhinskiy submitted his report on these matters to the State Nuclear Supervision Authority a half year before the accident. The blame for the failures rests with the Scientific Supervisor and the Chief Designer of the reactor.
3. The developer of the Test Program and the Chernobyl NPP personnel, who <u>**were not warned**</u> by the Chief Designer on potential "runaway" of RBMK type reactors in certain situations,

made the reactor enter a potentially dangerous mode. The blame for the failure rests with the Chief Designer, the top officials of the operating organisation - "Soyuzatomenergo" and top managers of the Chernobyl NPP.

Thus, so early as in June 1986, long before the court process in Chernobyl, the real causes of the accident and relative degrees of guilt of specific persons and organisations were clearly identified. A professional investigation, conducted by experts jointly with the Office of the USSR Prosecutor General, allowed to ascertain that "RBMK type reactors are intrinsically runaway-prone due to flaws in physical parameters and design of the reactor's active core".

Causes of the Chernobyl NPP accident and the guilty persons were identified with the maximal precision and listed in the Minutes of the session of the Politbureau of the CPSU Central Committee. However, the truth was intended for the highest Soviet rulers only - therefore the Minutes existed in the sole copy and were classified as a "Top Secret" document. As for the rest of the country's population, 17 days later, Pravda Newspaper (20.07.86) provided absolutely different information - "the truth on the accident for the general public":

"In the Politbureau of the CPSU Central Committee"

"The Politbureau of the CPSU Central Committee, at its special session, discussed the Report of the Governmental Commission on results of investigation of the accident at the Chernobyl NPP on April 26, 1986, on measures to mitigate its consequences and to ensure safety of the unreal power industry.

<u>The accident was found to happen due to a range of grave violations of the rules of operation of reactor installations by the NPP personnel</u>. At Unit 4, in the course of the reactor's shutdown for scheduled maintenance repairs, at night time, experiments were conducted - the ones associated with study to operation modes of turbine generators. Moreover, the NPP top managers and specialists had not prepared to the experiment themselves and did not agree the experiment with the relevant organisations, notwithstanding that they were obliged to. And finally, in the course of these works, the due control was not ensured and due safety precautions were not applied.

The Ministry of Power Industry and Electrification of the USSR and GAEN allowed lack of control over the situation at the Chernobyl NPP, failed to apply efficient measures to ensure compliance with the safety rules, to prevent deviations from the due discipline and rules of operation at the NPP… "

In short, the above "true" statement suggested that:

The accident was caused by a range of grave violations of the due operation rules of reactor installations by the NPP personnel and lack of control of the USSR Ministry of Power Industry and the State Committee of the USSR for

Supervision of Nuclear Power Industry over compliance with the due safety rules and operational regulations of the NPP.

Even a superficial glance allows to see a striking difference between the conclusions in the secret Politbureau Minutes and the ones published by Pravda Newspaper - they are absolutely different.

The personnel of the Chernobyl NPP were blamed and disgraced to the whole World. We hoped that the truth about the accident would be made restored in the course of the Chernobyl court process, but in vain. From that time, the real perpetrators of the accident successfully produced and widely disseminated the disinformation message that is still broadly accepted: "the real cause of the Chernobyl explosion has not been identified yet. There are more than a hundred different versions that should be considered as equally probable".

Let us return to Chernobyl. As the due NPP Nuclear Safety Rules of that time stipulated (para 5.19), that in the course of NPP operational period, the range of persons in charge of NPP nuclear safety incorporates the top NPP managers, the RS chief and the chief shift manager, six "Chernobyl scapegoats" were selected correspondingly. They included - the Director and the Chief Engineer (from the Administration), the deputy Chief Engineer and the chief of the Reactor Section (from the operational managers), the NPP chief shift manager (from the shift personnel) and the NPP Nuclear Safety Inspector. They were arrested long before the trial. Why were not they just restrained, say, under a recognisance not to leave? Were they expected to hide? It is a hardly imaginable situation. Were they able to interfere with the investigation? No, maybe just theoretically. The investigators were afraid that being free they could attract attention of different parties to deficiencies of RBMK type reactors and make foreign media interested in the matter.

They made all the necessary steps to deprive the Chernobyl NPP workers of any chances to influence their sentences that had been already awarded to them by the Politbureau of the CPSU Central Committee long before the trial. Should the court process be really open, with free competition of defence and prosecution parties on the equal footing, with involvement of independent experts, it would not become limited to prosecution of the Chernobyl NPP workers only. In such a case, dangerous properties of RBMK type reactors would be inevitably accounted for, and the issue of responsibility of RBMK reactor designers would be addressed. Unfortunately, at that time, and even now one can hardly expect to see holders of several stars of Heroes of Socialist Labour and members of the CPSU Central Committee as defendants in a court. Designers of RBMK type reactors were such "untouchables". A.P. Aleksandrov was the President of the USSR Academy of Sciences (1975 - 86), he had three stars of Hero of Socialist Labour and was a member of the CPSU Central Committee from 1966. N.A. Dollezhal had two stars of Hero of Socialist Labour, he was awarded the Lenin Prize and several State Prizes of the USSR. Moreover, the Politbureau had already set the vector of the Chernobyl trial at the session of May 5, 1986. It was stated by A.A. Gromyko, a member of Politbureau of the CPSU Central Committee, the Chairman of the Presidium of the USSR Supreme Council: “A disaster happened. Someone failed, committed a crime and must be punished. What had they intended to experiment with? The decision must be such to be remembered for generations to come!” [Tiktin S.A., The Chernobyl’s Smoke of Hell, SAMIZDAT Magazine, 2003].

Ten years after the disaster, Izvestia Newspaper correspondent L. Kapelyushniy wrote: “Before the case examination, the Office of the Prosecutor General explained to judges, experts and prosecutors in detail, who is guilty of what and how everyone should be punished, and what is the opinion of the CPSU Central Committee. As a result, the trial went very smoothly. If witnesses and experts said something wrong, they were provided just a couple of minutes and stopped” [Ten Years with Chernobyl. “Globus”, ## 185 - 188, April 1996].

The open trial in the restricted access zone

The town of Chernobyl was selected as the place for the court process against the accused in the accident fairly logically as, according to the Soviet law, a court should be conducted closely to a place of a crime committed. The town is located at the distance of merely 12 km from the NPP site, and the local residents were evacuated in early May 1986. As a result, nothing prevented them from declaring the court process open in the zone, accessible only for authorised persons.

After the accident, the town was decontaminated several times. The central part of the town was newly painted, roads were upgraded and marked, and, by July 1987, the administrative centre of the exclusion zone was completely ready to conduct a show-trial there.

The Culture Centre building selected for the court proceedings was carefully renovated. Its exterior view was just a little bit spoiled by grated windows and the newly constructed small closed patio, homing the car that delivered the accused to the court.

Some guests were invited - 60 Soviet and foreign journalists. All other seats in the court room were occupied by personnel of the Chernobyl NPP, the exclusion zone and the process participants.

The first session was scheduled to July 7, 1987. The journalists were allowed to attend only the opening session and the final one, to hear the indictment (in the first day) and the sentences. Details and circumstances of the accident were discussed at working sessions with a restricted access.

The trial lasted 18 days without weekends. The court sessions were opened at 11 a.m. and closed at 7 p.m. In the course of the court process, 40 witnesses, 9 victims and 2 affected persons were heard. At that time many people thought that the court materials would be accessible to all who want to know the truth about the Chernobyl NPP accident. However, the printed media and TV provided only short information on hot weather in Chernobyl and successes of harvesters. In such a way, a new information gap was made, this time in connection with the court aspects of the accident.

Unfortunately, in the course of the court process I was not relieved of my service duties at the Chernobyl NPP, as a result I was not able to record some court sessions and they are missing in this book. I made my records openly and many times some people with a characteristically gimlet gaze removed me from the court room to ascertain who I am and why I make these records. I explained that the records are necessary to train the NPP personnel, as I am the NPP chief on nuclear safety matters and I must be absolutely correct in terms of ensuring nuclear safety, of responsibility for non-compliance. It sounded convincingly and they allowed me to return to the court room.

THE INDICTMENT

7. 07. 87

Court session # 1

Participants:

The presiding judge - Raymond Brize, a member of the USSR Supreme Court.

People's assessors[11] - Konstantin Amosov and Aleksandr Zaslavskiy. Reserve people's assessor - T. Galka.

The state prosecutor - Yuriy Shadrin, a Counsellor in Justice 2nd Class, a Senior Assistant of the USSR Prosecutor General.

Secretaries - Shakin V.D. and Sokerin S.G.

Experts - members of the engineering expert team were appointed by a decision of the chief investigator, a Senior Assistant of the Prosecutor General of the USSR, a State Counsellor in Justice 3rd Class,

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[11] *Tr. note. Peoples' assessors were mock jurors of the Soviet justice system, colloquially called "yes-men"*

Potemkin Yu.A. on September 15, 1986 (Criminal Case # 19 -73, pp. 31 - 38 v. 38):

- Dolgov V.V.- a laboratory chief of the Moscow Physical Power Industry Institute, Cand. Sci. (Engineering);
- Krushelnitskiy V.N.- the Chief of 2nd Directorate of GAEN;
- Martynovchenko L.I.- the Chief of the Southern District Inspectorate at Kursk NPP;
- Minaev E.V.- a deputy Chief of the "Glavgosekspertiza"[12] of the USSR State Committee for Construction;
- Mikhan V.I.- a department chief of NIKIET, Cand. Sci. (Engineering);
- Neshumov F.S. - a department chief of "Glavgosekspertiza" of the USSR State Committee for Construction;
- Nigmatulin B.I.- a department chief of VNIIAES, Doct. Sci. (Engineering);
- Protsenko A.N.- a laboratory chief of IAE, Doct. Sci. (Engineering);
- Solonin V.I.- Professor, the Chair of Power Industry Machines and Installations of Moscow High Technical School, Doct. Sci. (Engineering);
- Stebok I.A.- a deputy department chief of NIKIET;
- Khromov V.V.- a chairholder of the Moscow Physical Engineering Institute, Doct. Sci. (Physics and Mathematics)

Defendants

- Bryukhanov V.P., the Director of the Chernobyl NPP, 52 years.
- Fomin N.M., the Chief Engineer, 50 years.
- Dyatlov A.S., the deputy Chief Engineer, 56 years.
- Kovalenko A.P., the chief of RS-2, 45 years.
- Laushkin Yu.A., the GAEN inspector at the Chernobyl NPP.
- Rogozhkin B. V., the chief NPP shift manager, 53 years.

Lawyers - three lawyers from Moscow and three lawyers from Kiev: Sorokin Yu.G., Solovyov M.I., Voronina O.N., Vaskovskiy V.S., Chupina L.V., Gretskiy N.N.

The beginning. The state prosecutor Yu. Shadrin stated [1], that the defendants are charged under para 2 of Article 220 of the Criminal Code of the UkrSSR, that stipulates criminal sanctions for non-compliance with occupational safety rules at explosion-prone facilities, that resulted in human casualties and other grave consequences. Besides

[12] *The Directorate for State Expert Assessment*

that, the defendants were charged under articles 165 and 167 of the Criminal Code of the UkrSSR for abuse of office and irresponsible fulfilment of their service duties.

Then, the presiding judge R.K. Brize started personal identification of the defendants. They raised, one by one, and told their personal information.

The court secretary read out the indictment for two hours.

The Director of the Chernobyl NPP and other defendants were charged in authorising conduction of a scientifically and technically underdeveloped experiment at the nuclear power plant, in violation of their service duties, that resulted in the disaster. As a result, Unit 4 was destroyed, the radioactive fallout contaminated the environment around the power plant, necessitating evacuation of 116 thousand people, including residents of two towns: Chernobyl and Pripyat. 30 persons died, including two persons in the moment of the accident and several hundred other people got radiation sickness of different grades due to radiation impacts.

After the accident, the defendants failed to take timely measures to reduce the accident's impacts on the NPP personnel and residents of nearby districts. Necessary rescue operations were not organised, people worked in the dangerous zone without radiation monitors to control radioactive contamination levels.

Attempts were made to forge information on real danger of the accident. For example, in the morning of April 26, the Director Bryukhanov reported to his service superiors and the Party authorities that the radiation levels at the NPP site and around it reach 3 to 6 roentgens per hour, while he was already informed by Civil Defence Chief of Staff that the radiation level in some areas reached 200 roentgens per hour.

The indictment stated also that other accidents happened earlier at the Chernobyl NPP but these accidents often were not analysed and even registered. The NPP top officials were also accused in failing to ensure the necessary professional training of the reactor operators and in failing to ensure the due control of personnel's workplace discipline.

WORKING SESSIONS

8. 07. 87.
Session # 2
Beginning at 11: 00.

Testimony of Bryukhanov V.P. , the former Director of the Chernobyl NPP [2]:

"First, I would like to say about the charges posed. On August 13, 1986, when I was accused, I submitted my written objections and disagreements on some charges. I do not agree with them. I am guilty as a manager, I failed to control something, I may have committed acts of negligence or mismanagement somewhere. I understand that the accident is grave, but everyone has his own faults in the accident".

Then Bryukhanov V.P. provided the account of his appointment to the Chernobyl NPP, and development of the NPP and the town, commissioning of the NPP reactor units (Unit 1 in 1977, Unit # 2 in 1978, Unit 3 in 1982 and Unit 4 in 1983).

"Commissioning of a laundry facility was more difficult than that of a reactor unit. If we posed requirements to contractors they said - you may look for other ones if we do not fit".

"Difficulties:

1) Only in 1983 or in 1984, we were allowed (by a Decree of the CPSU Central Committee and the USSR CM) to hire up to 30% of the personnel in two years before a unit commissioning date;

2) We did not have a TF[13], the NPP personnel did not have emergency operation skills. Smolensk TC[14] has not been commissioned yet. For two years we fought to have a TC of our own but we were authorised to have a TF instead".

"I managed to arrange allocation of funds for the computer, I managed to arrange supply of the computer itself, to arrange construction of the phone station building, the extra storey to the building and the display facility".

"Reactor units operated good, but in 5 years we had 100 malfunctions, i.e. 5 malfunctions per unit annually, including 33 personnel-caused ones (2 malfunctions per unit annually).

There were some accidents, as well as serious failures. We were seriously punished for them. But figures alone do not demonstrate anything without their analysis.

There was a team at the Chernobyl NPP (headed by Nazarkovskiy) that registered accidents and analysed their causes.

The indictment refers to some cases when accidents were concealed. I do not know such cases. I think it is impossible to conceal accidents. The grid control operator and the Ministry of Power Industry have displays that show current generating capacity of every power plant. Any power reduction will be immediately identified.

The NPP operations were under permanent control of a huge array of supervisory organisations. They issued many prescriptions. Yes, sometimes we failed to meet the deadlines specified and asked to extend them. And they

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[13] *Training Facility*

[14] *Training Centre*

usually allowed us to. Maybe we failed to grant extension of one by the moment of the accident, I will not insist that everything was in order".

The presiding judge *(Raymond Brize) - Have you familiarised yourself with the text of the indictment? Do you object to some specific facts pertaining to the accidents? If you agree with all the charges listed, why then do you provide us an account in general terms?*

Bryukhanov *- Directors, chief engineers and their deputies at NPPs are severely loaded. There is some division of labour duties between them, but the overall responsibility for their duties rests with them. I am charged in non-compliance with paragraphs 5.1 to 5.3 NSR. I knew, that Unit 4 would be shut down for preventive maintenance repairs. I knew that no special tests were planned. I had not seen that Program. Otherwise, I would take measures to coordinate it according to the standard procedure (the Chief Designer, GAEN, etc.). I will not deal with technical matters, as the competent conclusion of the technical expert assessment is available. There are documents, that were submitted by the USSR to the IAEA. I will not discuss them, they are correct.*

The presiding judge *- Did you know that the Program existed? You signed the commissioning protocol of the unit after its construction without there tests being completed. Did you recall it? Did you see the Program?*

Bryukhanov *- No, I had not seen it. I cannot know everything, it is impossible. I do not remember, that the commissioning schedule incorporated requirements to implement the Program. Some working commissions operated and they submitted their protocols to the State Commission. Being a deputy Chairman of the State Commission, I signed the Commissioning Protocol of Unit 4 as all the necessary works were completed.*

Bryukhanov *- As for Article 165 dealing with my actions as the Chief of the facility's Civil Defence. The charge specifies that I had to activate the plan for protection of the personnel and the general population. Yes, in formal terms, I had not activated the plan. When I arrived at my workplace on April 26, I gathered all technical managers and senior Civil Defence commanders. I set tasks to them.*

I was informed on the accident by the CS chief. The chief NPP shift manager (NPP CSM) and the on-duty phone operator did not call me. No emergency notification was made. I asked the phone operator why it was not made. She said that she did not know what particular record should be used. I told her to use the general accident record. When I arrived at the NPP I did not find the NPP CSM. I told the ES shift manager Sorokin to tell the NPP CSM my order to notify all about the accident immediately.

When I passed by Unit 4 and saw the scale of damage I assumed that the worst possible things happened. When I arrived at the NPP site I ordered the guards to open the shelter. Then I entered my office and tried to contact the NPP CSM by phone. He was not accessible. Then I run to the NPP site and reached the gas tank ERCS. It was destroyed. I returned to my office, tried again to contact the NPP CSM but in vain. Then, I was visited by Voloshko (the Chairman *of the city Executive Committee), the Second Secretary of the city Party Committee, the deputy NPP Director on security Bogdan and the NPP Party Secretary Parashin. I do not remember what I said at that time. Then, we moved to the shelter. I gathered unit managers of all services and NPP sections. I told them what had happened. I told them that I do not know details, that it is necessary to take measures for removal of personnel from the NPP site, to use the minimal number of workers. I set tasks to the deputy chief of the Occupational Safety Dept. Krasnozhen and the chief of ERM Laboratory Korobeynikov.*

The chief of communications told me that the phone connection was switched, and I started my report to the superiors (to the Directorate Chief - that a serious accident happened, Unit 4 was destroyed, no details are known so far), and I told Vorobyov to maintain permanent contacts with the oblast-level Civil Defence Command. Then I called the oblast Party Committee and asked to connect me with 1st Secretary but they connected me with 2nd one and then I reported to the First Secretary. I reported to the deputy Minister of Power Industry of the UkrSSR, to the Minister and to the Director General of Kievskaya oblast Power Supply Utility. Then, I again called the Chief of the Directorate Veretennikov. Then reports from our specialists on the unit parameters started to come. Information from Krasnozhen was submitted.

Then the NPP CSM called, he said that an explosion happened, that attempts were made to supply water to the reactor, he did not know details.

We, the power industry specialists, were sure that a "chill" in the reactor is the worst possible thing. As both right and left side separators displayed no water level, that was the most dangerous thing.

I cannot link all events in a time sequence. I arrived at the NPP site not later than on 2 a.m., I remember that.

Then I was approached by Parashin and Belichenko, a sector chief of the oblast Party Committee. I reported the situation and he said that the Second Secretary of the oblast Party Committee Malomuzh was heading to the Chernobyl NPP. Belichenko asked to produce an information note for him. Parashin offered to do it. He sais that he with Belichenko would produce it and show me. The note specified 1000 μR/hour at the NPP site (10 μSv/hour) and 2 - 4 μR/hour in the city (0.02 - 0.04 μSv/hour).

I ordered Rakitin (the Secret Documentation Dept. Chief of the Chernobyl NPP) to print the note, he asked me who should be specified as the responsible person for it?

I told him to show the note to the Chief Engineer and - should he agree - to specify him. I do not know whether he showed the note to Fomin or not. Later, he delivered the printed letter to me and I signed it.

Then, Voloshko gathered chief managers of Pripyat facilities in the city Executive Committee and briefly informed them on the accident. Then, I moved to the NPP. A little bit later, I was again requested to the city Executive Committee. At that time, the Minister and his deputy Semenov were present *there. They proposed me, Konviz and someone else to prepare measures for restoration of Unit 4. We spent some time dealing with the assignment. Then, I moved to the NPP again and I was again requested to the city.*

Then I had a lot of assignments. The Governmental Commission moved to Chernobyl while I stayed in Pripyat and then moved to "Skazochniy" summer camp.

I did not intend to conceal anything, I used the information I got from Krasnozhen and Korobeynikov. Later, I was told that the same information was available in the city Party Committee, I do not know who provided the information to them.

(break from 12:30 to 12:45)

***Bryukhanov**: I think that I organised the radiation surveillance. Krasnozhen was ordered to stay at the NPP site and prevent people's entry to inaccessible places (verbatim). They reported the radiation level to me - up to 1000 µR/sec (36 mSV/hour).*

Vorobyov told me about 30 - 35 and 40 - 50 roentgens per hour (up to 0.5 Sv/hour). Yes, it was so. I personally moved to the western and northern sides of the NPP and made personal measurements, I saw levels up to 200 R/hour (2 Sv/hour). It was a streaming radiation, but we all know that there are unattended, semi-attended and attended facilities at the NPP site… I myself and all others knew that radiation levels nearby the damaged unit would be higher.

As the Director I could not issue radiation meters to everyone. These instruments were available in the Occupational Safety Dept., in ERML[15], in the Civil Defence command centre. They were used and issued there. According to the Civil Defence equipment table we had 100% supply, all the documents reflect that.

I was charged in a failure to prepare protection facilities. This is not true. The shelters were constructed fully, the oblast level Civil Defence command had relevant reports. Besides that, exercises were conducted. As for shelter # 2, yes, some equipment items were stored there, but these items belonged to the Civil Defence command, it is not prohibited. Besides, the shelter was located nearby the damaged unit, as a result I did not order to use it.

As for shelter # 3, I do not know why the unit chief did not order to use it.

I told unit chiefs to reduce numbers of people in the zone, as a result I do not know, why the shift personnel arrived in full force.

As for the evacuation: I did not activate the plan formally. It was necessary to make specific actions according to the plan. I started to act according to the plan. Informally I made everything according to the plan. I ordered to make emergency notification, to report to the Civil Defence command. It would be

[15] *The External Radiation Monitoring Laboratory*

sufficient to say, that the Governmental Commission arrived - the fact confirms efficient notification.

Issues of alerting the city and evacuation of the city residents are outside my sphere of competence. I could not make it. Besides that, there was a clarification that the Civil Defence commander may decide at the cumulative dose of 200 roentgens (2 Gy), while on April 26, the dose might be below 0.64 R (6.4 mGy).

That is all I wanted to say.

***The presiding judge** - Does the prosecutor have any questions?*

***The prosecutor** - Yes.*

***The prosecutor** - Did you comply with the "Personnel Management Guidelines" fully?*

***Bryukhanov** - Yes.*

***The prosecutor** - What had prevented you from establishing a TC? Why it was absent at the NPP while you were the NPP Director?*

<u>Bryukhanov remains silent</u>.

***The prosecutor** - It is clear that you did not raise such questions.*

***Bryukhanov** - I raised them in the Ministry and in the Directorate.*

***The prosecutor** - You said, that the personnel were not prepared to work in emergencies, i.e. they were not trained sufficiently.*

***Bryukhanov** - No, the personnel were prepared in full compliance with the Guidelines.*

***The prosecutor** - Why personnel admittance to work (including back-up support) was managed by NPP sections instead of the NPP top managers?*

***Bryukhanov** - the chief unit shift manager, chief shift managers are subordinated to the NPP top managers, CE deputies, the NPP CE. Admittance of other shift personnel is decided by sections' top managers (verbatim - N.K.).*

***The prosecutor** - That is the violation.*

***The prosecutor** - Once in a month (according to the Guidelines) you were obliged to make rounds of personnel's workplaces. Did you comply with the requirement?*

***Bryukhanov** - Those are so called "night rounds". Yes, I could not do them in 1986, due to my workload. But I made daily rounds (the turbine room, unit CRs, etc.).*

***The prosecutor** - There are certain procedures, a log of inspection rounds should be maintained. The last entry you made is dated 1978. There is your order to make inspection rounds 2 - 3 times in a year - the one issued in 1986. Who had authorised you to revoke the Guidelines?*

***Bryukhanov** - I do not remember such an order.*

***The prosecutor** - You issued it in 1986.*

***The prosecutor** - As for the exams. The range of top officials includes only the NPP Director and the Chief Engineer. But examination commissions were chaired by deputies of the Chief Engineer. It is wrong.*

Bryukhanov *- But they examined their subordinate personnel only, by NPP stages.*

The prosecutor *- We interpreted the Guidelines unequivocally - the range of top officials of a facility incorporates only its director and chief engineer.*

The prosecutor *- How did you meet requirements to investigation of accidents? Have all the accidents been investigated completely?*

Bryukhanov *- There were some accidents, whose causes the commission failed to identify.*

The prosecutor *- I can show you a protocol that lists the accidents that were not investigated at all. The protocol is incorporated into the case file materials, you familiarised yourself with it, do you deny the fact?*

Bryukhanov *- No, I do not deny.*

The prosecutor *- In the first quarter of 1986 you disabled safety and interlocking systems 6 times (from February 6 to April 26 - according to the log entries of the deputy chief of TICS). These actions were made without agreeing with the superior authorities. Those are deviations.*

Bryukhanov *- I did not know that, but I can explain. It is not appropriate to shut up a reactor unit due to some minor reasons.*

The prosecutor *- This is wrong, this is against the rules.*

The prosecutor *- Had you signed the Commissioning Protocol of Unit 4 without completion of the rundown test program?*

Bryukhanov *- Yes, I commissioned the minimal operational configuration.*

The prosecutor *- Later on, you had to adjust the unit up to its design requirements. The program had been already run in 1982 for Unit 3 (before the launch of Unit 4) and in 1985. Did you know about that?*

Bryukhanov *- No.*

The prosecutor *- Let us speak about the Civil Defence. The Protocol of the Civil Defence commission of January 1986 states that shelter # 3 was unusable.*

Bryukhanov *- I think that the shelter was ready.*

The prosecutor *- Did you see the Protocol?*

Bryukhanov *- Maybe.*

The prosecutor *- As for the accident - after the accident the personnel complained that preparedness to emergency drills was poor.*

Bryukhanov is silent.

The prosecutor *- The personnel claim that the emergency alert notification was conducted in a spontaneous manner. What were you obliged you do?*

Bryukhanov *- I think that I met all the requirements.*

The prosecutor *- By 3 a.m. of April 26, you already knew that radiation intensity nearby Unit 4 reached 200 R/hour (2 Sv/hour). Did you realise that later the situation would worsen?*

Bryukhanov *- I knew, that the dose intensity was primarily defined by iodine and I was sure that the intensity would decline. As for the figure of 200 R/hour (2 Sv/hour), etc. such intensity was observed only in the zone of direct radiation streaming.*

The prosecutor *- Why, then, had not you removed the people from the impact zone?*

Bryukhanov *- I ordered to remove all excessive personnel, but we could not leave the reactor without control.*

The prosecutor *- The letter to Soviet and Party authorities did not incorporate information on 200 R/hour (2 Sv/hour. Why?*

Bryukhanov *- I did not read the letter closely, surely, that should have been added.*

The prosecutor *- But that was the most serious issue of yours, why had not you done it?*

Bryukhanov is silent.

The prosecutor *- At the meeting in the city Executive Committee, Voloshko said whatever he wanted. Why did not you stand up as the most informed person there and say the truth?*

Bryukhanov *- Yes, I had to stand up and say ...*

The assistant prosecutor *- Did you know that Kharkov specialists would measure vibration of the turbine generator?*

Bryukhanov *- I knew that it is always done. We always did it.*

The assistant prosecutor *- For several years, rundown tests were conducted and always failed. Did not you know about that?*

Bryukhanov *- I did not know.*

The assistant prosecutor *- Are not you interested in operational issues?*

Bryukhanov *- I was interested a lot, but I could not know everything, technical specialists are available for these matters.*

The assistant prosecutor *- What is a "general accident"?*

Bryukhanov *- It is a radiation accident, affecting the reactor and the NPP site.*

The assistant prosecutor *- At about 2 a.m. you ordered the phone operator to activate the alert notification. Why did not you repeat the order within the day?*

Bryukhanov *- Yes, formally, I did not do that.*

The assistant prosecutor *- When you approached the NPP, what did you see - a fire, a glow?*

Bryukhanov *- Only a slight glow. It was at night. In the daytime, we circled the reactor in the helicopter, only two craters were visible there.*

The assistant prosecutor *- What did you do when you were relieved from the Director's position and expelled from the Party?*

Bryukhanov *- I started to work since August.*

The assistant prosecutor *- There is some information that you had your rest in Yalta.*

Bryukhanov *- I worked until I was relieved by the Minister. Then I went to my family.*

The prosecutor *- Please, provide your assessment of the program and the events.*

***Bryukhanov** - As for the program, I think that there were many deviations. The program was not agreed with GAEN, the Chief Designer, the Scientific Supervisor, and "Gidroproekt". Personnel actions were not clearly defined, particularly in connection with discharge of excessive steam. As for disabling the safety systems I do not see any sense. I think that the operation (verbatim - N.K.), should be conducted on a shutdown reactor.*

***The expert** - Who had approved the comprehensive plan of new equipment development?*

***Bryukhanov** - I do not remember.*

***The expert** - What was the Program - was it a research or some regulatory checks?*

***Bryukhanov** - I think that it was a test of the maximal load of a generator at rundown.*

***The expert** - Did you ask the phone operator to activate the emergency alert notification on the "general accident" personally?*

***Bryukhanov** - I did it via the chief shift manager of ES.*

***The expert** - But just an hour ago you said different things.*

***The expert** - In the course of the pre-trial investigation, you said that you were in the area of Unit 4 nearby the canteen, with Vorobyov and Solovyov. But they strongly deny that.*

***Bryukhanov** - Maybe I was with Korobeynikov, not with them. I do not remember.*

***The expert** - Why did you pump water to the reactor when you knew that it was destroyed?*

***Bryukhanov** - Water was pumped on April 26 only, on April 27 we tried to remove water.*

***The expert** - There is some information that the chief of the Occupational Safety Dept. Kaplun did not know what to do. Why did not you work with him?*

***Bryukhanov** - I worked with Krasnozhen.*

***The expert** - How many information notes had you produced for the city Party Committee, one or two?*

***Bryukhanov** - I made only one information note. It was signed by me and the chief of the external radiation monitoring laboratory Korobeynikov.*

***The expert** - Do you consider yourself and other top managers of the NPP sufficiently educated to make conclusions on the accident?*

***Bryukhanov** - I do not consider myself a specialist in the sphere, but we had specialists in physics.*

***The expert** - Did they say about potential consequences of the accident?*

***Bryukhanov** - There were no such talks in my presence.*

***The expert** - Did you feel yourself ill, is there a medical certificate?*

***Bryukhanov** - No. I was in good health.*

***The expert** - Why did you go to the South?*

***Bryukhanov** - Doctors recommended me the Baltic coast, but the climate these is too cold for me. I am exhausted.*

The presiding judge *- Does anyone have questions?*

Sitnikova *(the widow of deputy Chief Engineer A. Sitnikov, who died from acute radiation sickness) - Viktor Petrovich, who should have taken responsibility for making a radio alert, advising people to close doors and windows but had failed to do it?*

Bryukhanov *- The city Executive Committee, I think.*

Sitnikova *- Did you tell them that?*

Bryukhanov *- I do not remember.*

Sitnikova *- When you had arrived at the NPP, you already knew the situation in general terms. Why did you send my husband to Unit 4?*

Bryukhanov *- I ordered Sitnikov and Chugunov to go to Unit 4 CR and take Dyatlov here. Nothing more. Chugunov can confirm that.*

(**V. Chugunov** [1] - **the Director and the Party Committee Secretary ordered** me and A. Sitnikov:

- first - to check operation in the emergency cooling mode;
- second - to help in search from the people missing (by that time, six more persons were missing);
- third - to estimate boundaries of the demolition zone and assess options to localise the accident).

(break for 1 hour, from 14 to 15)

Questions of defence lawyers to Bryukhanov.

Bryukhanov's defender *- As for para 2.2 of the Personnel Management Guidelines - in this connection you are charged in poor training of the shift personnel. Please, explain how do you understand that?*

Bryukhanov *- A new person cannot be appointed to a position without training. Back-up arrangements are defined by orders of deputy CE and the NPP CSM. An individual approach is applied to all persons.*

Bryukhanov's defender *- As for the inspection rounds at workplaces - why did not you conduct these rounds?*

Bryukhanov *- I did not notify the inspector in charge of maintaining the log on my rounds. I made relevant verbal remarks in the course of operational briefings. My serious reprimands are reflected in orders.*

Bryukhanov's defender *- What measures did you take to investigate accidents at the Chernobyl NPP?*

Bryukhanov *- Commissions were established to investigate accidents and protocols were compiled on the matters.*

The prosecutor *- Some accidents were not investigated. There is a protocol of technical expert assessment. Do you agree with its conclusions?*

Bryukhanov *- The protocol only provides numbers of accidents per annum and does not specify them. As a result, I cannot answer the question unequivocally.*

The prosecutor *- So, we will read the protocol out fully.*

Bryukhanov's defender *- How did your superiors consider the accidents' investigation protocols?*

Bryukhanov *- Differently. In some cases they recategorised accidents.*

Bryukhanov's defender *- As for the program - was it possible to note in 1983, that the program was not completed prior to commissioning of the unit?*

Bryukhanov *- It was possible. But it was allowed to do it without completion of the program. One just needed to complete it himself later on.*

Bryukhanov's defender *- Does the design stipulated a potential accident at Unit 4? Was a specific personnel training conducted for such an accident?*

Bryukhanov *- No.*

Bryukhanov's defender *- Could the trainings to cope with design-basis accidents help the personnel in that accident?*

Bryukhanov *- Yes it could.*

Bryukhanov's defender *- Does the Plan of Measures for Protection of the Personnel and the General Population specify who should do what, how many personnel should be retained, where family members should be evacuated to?*

Bryukhanov *- Yes, everything was specified in details.*

Bryukhanov's defender *- So, it was not necessary to itemise tasks for unit managers?*

Bryukhanov *- I think, it was not necessary.*

Bryukhanov's defender *- As for the radiation situation - did you have a complete objective picture at the base of information provided to you by the specialists?*

Bryukhanov *- Yes. I think that they provided me everything, by phone and according to charts, on main workplaces. Handwritten notes were also provided, notes with drawings, dose loads.*

Bryukhanov's defender *- When did the military and the Civil Defence Corps intervened? What information did you get from them?*

Bryukhanov *- I do not remember a precise time, it was around midday, but I did not get any information from them.*

Bryukhanov's defender *- Did you have sufficient data to activate the plan of measures?*

Bryukhanov *- Yes. I think that the data I got allowed to do it.*

Bryukhanov's defender *- Did you provide objective data to the oblast Party Committee?*

Bryukhanov *- By that time, higher levels were also known, but I read the information note superficially and did not specify them.*

Fomin's defender *- Did Fomin participate in drafting the information note?*

Bryukhanov *- No.*

Fomin's defender *- Why then did you specify him as the note's responsible person?*

Bryukhanov *- I already said how it happened.*

Fomin's defender *- The chief of the Secret Documentation Dept. Rakitin said that you clearly ordered him to specify Fomin.*

Bryukhanov is silent.

Fomin's defender *- When had you met Fomin?*

Bryukhanov *- I cannot tell a precise time, it was in the morning.*

Fomin's defender *- Did you discuss radiation levels with him? Were the data supplied to you only?*

Bryukhanov *- I did not discuss. The information was supplied to me only.*

Fomin's defender *- Did you have a sufficient body of information to make a decision on evacuation timely?*

Bryukhanov *- According to data of Academician Blokhin, published in "Radyanska Ukraina" Newspaper, I understood that the evacuation was conducted in time.*

Dyatlov's defender *- When had you seen Dyatlov?*

Bryukhanov *- I encountered him in the bunker at about 6 a.m. I asked him what happened? He helplessly raised his hands, said that he could not explain and handed me recorder strips of 4 recorders of the unit. I told him to go to a clinic.*

Dyatlov's defender *- How did Dyatlov looked?*

Bryukhanov *- He was pale. He felt sick.*

Kovalenko's defender *- Was the program an experimental or a standard operational one?*

Bryukhanov *- It was rather operational.*

Kovalenko *- Were the Chernobyl NPP and the reactor unit categorised as explosion-prone? What documents regulated these matters?*

Bryukhanov *- The answer to this question is provided in the investigation materials.*

Rogozhkin's defender *- Who was expected to notify you on the accident?*

Bryukhanov *- The NPP phone operator and the chief NPP shift manager.*

The presiding judge *- Rogozhkin, do you have questions to Bryukhanov?*

Rogozhkin *- No.*

Laushkin's defender *- Was the GAEN inspector present at the operational briefing of April 25?*

Bryukhanov *- No.*

Laushkin's defender *- Were there prescriptions from Laushkin?*

Bryukhanov *- I dealt with Frolovskiy and Elagina.*

Laushkin's defender *- Were there prescriptions from GAEN?*

Bryukhanov *- Yes, a large number of.*

Laushkin 's defender *- Did Laushkin participate in investigation of accidents?*

Bryukhanov *- He signed some investigation protocols, but I do not remember more precisely.*

The presiding judge *- Laushkin, do you have questions to Bryukhanov?*

Laushkin *- I do not have questions to Bryukhanov.*

The presiding judge *- Bryukhanov, after the indictment we asked you whether you plead guilty. You said - yes, I am guilty. But now you say that you are not guilty.*

Bryukhanov *- I am guilty in negligence as a manager. But as for those articles - I do not understand them.*

The presiding judge *- Now you say, that everything was good, that you did all you had to, in other words, that you are not guilty and plead non-guilty. There were difficulties with the training simulator, you did not know about the program, you signed the unit Commissioning Protocol without knowledge of the failure to complete the program. Where then, do you see your guilt, tell us please to know your position?*

Bryukhanov *- In lapses and overlooks.*

The presiding judge *- Where are there lapses and overlooks?*

Bryukhanov *- In all issues raised by the investigation.*

The presiding judge *- The expert asked you on the program. When the tests were conducted, what, as you think, were the deviations of the personnel?*

Bryukhanov *- It was a lack of coordination. Launching 4 reserve pumps in addition to 4 already operating ones. It was not clear where the excess steam should be discharged to.*

The prosecutor *- The program was approved when you were the Director. You specified its deficiencies. How could it be put into operation?*

Bryukhanov *- It is hard for me to answer this question. I considered the NPP Chief Engineer as a strict, professional engineer.*

The presiding judge *- Who is responsible for the overall occupational safety management at the NPP, for all other safety issues?*

Bryukhanov *- The supreme administrator is in charge of the overall management.*

The presiding judge *- As I understand, the overall management entails the overall supervision. Am I correct?*

Bryukhanov *- I do not deny it.*

The prosecutor *- You were familiarised with the case materials. Do you have questions on the program execution?*

Bryukhanov *- Low power, 200 MW instead of 700 to 1000 . Low ORM (1.9 OCRs*[16] *by the moment of the accident). Besides that, the reactor power was allowed to decrease to zero (Toptunov). It is not clear why the second pump was switched on. Then, if the tests were postponed, the emergency reactor cooling system should be enabled.*

The presiding judge *- All these facts concern April 25. Do you have any critical comments on April 26?*

Bryukhanov *- It was necessary to wait for the poison override after the power fall to zero. SDS-5 safety system should not be disabled.*

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[16] *Operator-controlled rods*

The presiding judge *- How could you explain these deviations of your personnel. But then, you promoted Fomin and Dyatlov.*

Bryukhanov is silent.

The presiding judge *- Were they awarded for introduction of new equipment, were they awarded some bonuses?*

Bryukhanov *- I cannot recall now.*

The prosecutor *- You said that you had no problems with personnel training, and then you yourself assessed actions of your subordinates negatively. How should we understand that?*

Bryukhanov *- Maybe, those are my omissions.*

The prosecutor *- Protocols often referred to insufficient professional training of your subordinates. Is it correct?*

Bryukhanov *- Maybe it is correct.*

The prosecutor *- Experts suggest that the measures to remediate critique of GAEN were of formal nature. The real situation did not change, grave deviations from the technology continued. Why did not you take efficient measures?*

Bryukhanov *- We sought to remediate critical comments, but it seems that we failed to do it in a timely manner always.*

The prosecutor *- Do you have to maintain a training and methodological council on the personnel training matters?*

Bryukhanov *- I do not know.*

The prosecutor *- You do not know answers to many questions we asked. Tell us please, did you feel yourself confidently as the director?*

Bryukhanov *- Confidently.*

The presiding judge *- Maybe, it is your confidence that got you into trouble.*

The presiding judge *- Were you required to have training simulators?*

Bryukhanov *- They were not stipulated by the NPP project.*

The presiding judge *- When had you got information on radiation levels in excess of 200 R/hour (2 Sv/hour)? The indictment specifies about 3 a.m. Do you deny that?*

Bryukhanov *- No, I do not deny.*

The presiding judge *- When did you signed the information note for the Party authorities?*

Bryukhanov *- At about 11 a.m.*

The presiding judge *- Why did not you specify the real radiation exposure dose?*

Bryukhanov *- I simply did not thought when I signed it.*

The prosecutor *- Did you trust Vorobyev, Solovyev and their data?*

Bryukhanov *- I trusted.*

The prosecutor *- Why, then, did you prohibited them to disclose the data?*

Bryukhanov *- There were many different amateurs who called high authorities. I did not want the information to be leaked to some incompetent persons.*

The prosecutor *- In the course of investigation they testified that you did not want to listen to them. How could you explain that?*

Bryukhanov *- I told them to maintain contacts with the Civil Defence Command and do not call other organisations.*

A people's assessor *- How did you control execution of your orders?*

Bryukhanov *- By the computerised assignments' follow up alert system. Unit managers reported by the end of a month.*

The people's assessor *- Who, as you think, is guilty in the accident?*

Bryukhanov *- The court will decide who.*

The prosecutor *- Do you consider yourself as the principal offender?*

Bryukhanov *- I think that the shift personnel, Dyatlov and Fomin are.*

The people's assessor *- But what about you as the supreme administrator?*

Bryukhanov *- Me too.*

The people's assessor *- Was there a system of radiation sensors at the Chernobyl NPP?*

Bryukhanov *- Yes, "Gorbach" system.*

The people's assessor *- What kind of instrument was used to register EDRs over 200 R/hour (2 Sv/hour)?*

Bryukhanov *- Only inside the NPP. In the city and at the NPP site the External Radiation Monitoring Laboratory operated.*

The people's assessor *- How do you think, should such instruments be installed in the environment?*

Bryukhanov *- Maybe, not. Associated costs are too high.*

The people's assessor *- You knew about the radiation levels. Lives of many people weight heavily upon your conscience. Did you at least order buses to evacuate people from the NPP?*

Bryukhanov *- I could not tackle evacuation matters in isolation from the city evacuation.*

The prosecutor *- All waited for you to signal, while you waited for others.*

Bryukhanov *- I had no means to do it.*

The defender *- If the program would have been conducted without deviations, could the accident happen?*

Bryukhanov *- No, it could not.*

(break from 16:30 to 16:45)

The presiding judge *- **Defendant Fomin**, what would you like to say in connection with the charges against you.*

Fomin *- Let me use notes, please. (He made a long account of his emotions, anguish, condolences to the dead - N.K.). I am sure that the program was not the cause of the accident. No explosions happened in 1982 and 1985.*

Witness M. Umanets testified that the program, if conducted in compliance with the Regulations, would ensure safety of the reactor. The accident was caused by deviations from the program - in the power level, in a low operational *reactivity margin, in disabled safety systems. Due to a poor training of the CRCE the reactor's power had fallen to zero.*

As for the personnel training, we followed the Guidelines, the Technical Operation Rules, NSR, etc. Training simulators were needed but we still do not have them. According to leading nuclear physicists, RBMK type reactors are unsafe. Volkov, a leading physicist of the Nuclear Energy Institute, expressed his considerations on alterations of the active core composition. Eleven commission members agreed with him. Nevertheless, these factors could not cause the accident without the deviations.

Due to my heavy workload in connection with repairs and operational issues, I had to rely on the deputy Chief Engineer for science Lyutov on nuclear safety matters. On 25.04.86, he knew that the program was being prepared, but he and specialists of the Nuclear Safety Dept. failed to act duly.

Working for twelve hours a day or more, working at weekends, I had prepared the memo on adjustment of the NPP management structure, on transformation of the third phase of the plant into an independent NPP. Accidents-related issues consumed a lot of time. We had lesser accidents than other NPPs and the Chernobyl NPP worked more smoothly than others. Maybe, I focused on these issues and paid insufficient attention to supervision of activities of my deputies. Besides that, it is necessary to note that I was ill for a long time, I had a spine fracture 4 months before the accidents.

I did not participate in assessment of the radiation situation.

As for the shift personnel, who arrived in the morning of April 26 - they were needed for cooling of Unit 3.

According to Krasnozhen, EDR inside the turbine room building did not exceed 1000 μR/hour. Therefore, we kept the personnel there for accident-related operations.

As for the emergency alert notification, I thought that the Civil Defence commander and the Director had already made it. Of course, it should have been backed up.

That is all.

***The presiding judge** - Why had you approved a program, you yourself considered wrong?*

***Fomin** - In 1982, 1984 and 1985, in the course of conducting the program, the reactor's SDS-5 was activated by a signal of closure of the turbine steam supply valve. But in 1986, changes were introduced in this connection. Now, it is clear for me that the program should have been agreed with specialists. There was no need to maintain a power level of the apparatus if steam supply to all TGs was cut off.*

Installation of the MCA button did not affect the accident's course, as we used only a part of the safety system's circuit.

As for activating four MCPs at each side of the reactor - it is not a deviation. Such conditions emerge, for example in a trip on MCPs.

As for the steam discharge, its discharge through the condenser's reducer valve was stipulated.

Disabling the ERCS is a violation, but it did not cause the accident. I consider deviations from the program as the main cause of the accident, first of all, the reduction of the reactor's power down to 200 MW.

***The prosecutor** - Why was not the Training and Methodological Council established - the one you were to chair?*

***Fomin** - The relevant prescription was issued to us in 1983. I thought it was completed. Nazarkovskiy supervised these matters.*

***The prosecutor** - unit CSMs, NPP CSMs, shift managers were not admitted to work independently and as back-up personnel by the NPP top managers. Why?*

***Fomin** - According to the Technical Operation Rules, these functions should be fulfilled by the Director, the Chief Engineer and their deputies.*

***The prosecutor** - Why did not you comply with the schedule of workplace rounds and review of operational documentation?*

***Fomin** - I made my inspection rounds regularly, but I did not register them.*

***The prosecutor** -The last entry is dated 18.03.85, was it your last inspection round?*

***Fomin** - I returned to work in late February 1986, I operated in the office, as walking was accompanied by pain. Doctors recommended me to stay at home, but I returned to my duties for the sake of work.*

***The prosecutor** - Why did the job descriptions lack the necessary requirements to functions of relevant chiefs? Why had the chief of RS-2 drafted his job description himself?*

***Fomin** - Job descriptions are approved by the Director.*

***The prosecutor** - Why did not you investigate all cases of accidents and malfunctions?*

***Fomin** - I followed up all accidents and malfunctions. But Nazarkovskiy proved to maintain the relevant records unduly. I thought that he worked scrupulously.*

***The assistant prosecutor** - Who was the initiator of the test?*

***Fomin** - The tests were initiated by the Electric Section, however, they actually do not need the relevant mode. But the mode was specified in the design documentation, so we needed to implement it. Inspectors criticised us for the lack of it.*

The Electric Section just needed to check and tune the relevant parts of electric circuits.

***The prosecutor** - Did Bryukhanov know that the program would be run?*

***Fomin** - He says that he did not know.*

***The prosecutor** - Did you tell him about that?*

***Fomin** - No, I did not tell him.*

***The prosecutor** - As you think, what could prevent the accident?*

Fomin *- Had not SDS-5 on closure of emergency regulating valves be disabled, the unit would remain intact.*

The prosecutor *- Well. But why then is the Program silent about that? Why did not the safety section specify that it is prohibited to do such things? Where are Lyutov and physicists in the program? Why are only electric engineers referred to there?*

Fomin is silent.

The prosecutor *- Why was the ERCS disabled?*

Fomin *- This is a deviation from the Regulations and key safety requirements.*

The prosecutor *- Why were not physicists involved, whom had you agreed the appropriate power level for the tests with?*

Fomin *- We discussed the power level in detail with Lyutov and Gobov.*

The prosecutor *- Who, as you think, is the key causer of the accident?*

Fomin *- Dyatlov and Akimov who deviated from the program.*

The prosecutor *- When had you got information on high radiation levels?*

Fomin *- While going to Unit 4. At about 5 a.m. I met Krasnozhen. I asked him about the situation, he answered "I am clarifying it". I told him to report me on the situation at Unit 4 CR. Later on, Glebov and others drafted an outline radiation map of the NPP site.*

The prosecutor *- You always were with Bryukhanov. Did not you ever discussed the radiation parameters with his? Did you meet Dyatlov?*

Fomin *- No.*

The prosecutor *- Did you know that more than 100 people were hospitalised that morning?*

Fomin is silent.

The prosecutor *- Were you present at the meeting in the city Executive Committee?*

Fomin *- I was not present at the meeting chaired by Voloshko. I was at the Minister's meeting.*

The assistant prosecutor *- Unit 4 was commissioned on 31.12.83 without the tests of the rundown system. Did you know about that?*

Fomin *- Yes.*

The assistant prosecutor *- Did Bryukhanov know about that? Have you reported that to him?*

Fomin *- No. There are many such issues at similar facilities.*

Thee assistant prosecutor *- Had you decided to conduct the tests yourself or you were ordered to by your superiors?*

Fomin *- I did it myself.*

The assistant prosecutor *- Who approved conduction of the program in 1982, 1984, 1985 and on whose* orders?

Fomin *- I approved it myself, without orders.*

The assistant prosecutor *- Who managed works under the program?*

Fomin *- I managed.*

The assistant prosecutor *- Did the Director know that rundown tests were under way?*

Fomin *- No.*

The assistant prosecutor *- Did you tell him?*

Fomin *- No.*

The assistant prosecutor *- What is connected to the rundown system?*

Fomin *- Electric feedwater pumps.*

The assistant prosecutor *- And what had you connected?*

Fomin *- The feedwater pumps. However, in such a case, power is supplied to all installations connected to the section, including MCPs.*

The assistant prosecutor *- Did the design stipulate that?*

Fomin *- Yes.*

The assistant prosecutor *- When the accident happened at TG-7 in 1985, was it also associated with rundown tests?*

Fomin *- No.*

The assistant prosecutor *- When should Unit 4 have been shut down and who had altered the date?*

Fomin *- 23.04.86, but later we decided to cool the reactor down on the weekend.*

The assistant prosecutor *- Was there an order to shut down the unit and whose order was it?*

Fomin *- There was the Director's order to shut down the unit for preventive repairs and maintenance.*

The assistant prosecutor *-You approved the program on April 21, and on April 23 the program was to be conducted. Was the time sufficient to study the program?*

Fomin *- The draft program was preliminary agreed with all the units participating.*

The assistant prosecutor *- Did the Director know about the program's rescheduling?*

Fomin *- He knew.*

The assistant prosecutor *- Who sent the cable to Kharkov, requesting specialists to come and what for? Who decided on payments for the tests? (more than 6000 roubles.)*

Fomin *- I sent the cable, it was necessary to conduct vibration tests of TG-8.*

The assistant prosecutor *- Did the Director know about the pay?*

Fomin is silent.

The assistant prosecutor *- Did you see the program of the vibration tests?*

Fomin *- I saw it in the course of the investigation.*

The assistant prosecutor *- Were you obliged to review it before commencement of the works?*

Fomin *- It is of a model format.*

The assistant prosecutor *- Did you know for sure that the vibration tests were conducted simultaneously with the rundown?*

Fomin *- I had no idea.*

The assistant prosecutor *- Are those two tests compatible?*

Fomin *- They are incompatible. They require different operation modes of turbine generators.*

The assistant prosecutor *- Do you know that it was one of the causes of the accident?*

Fomin *- It is impossible to make such a conclusion based on the investigation materials.*

The assistant prosecutor *- Did Bryukhanov know that the vibration tests were to be conducted?*

Fomin *- I do not know.*

The assistant prosecutor *- Tell me honestly, did Bryukhanov know about the rundown?*

Fomin *- No.*

The assistant prosecutor *- Is it your guilt that you had not told him?*

Fomin *- (after a prolonged silence) - Mine.*

An expert *- Tests of 1982 were different comparatively to tests of 1986. At that time, the MCA button was not used, and 4 MCPs at each side of the reactor were not operated.*

Fomin *- It was the first experiment and we were cautious.*

The expert *- Why did you fear injection of cold water from ERCS to the reactor?*

Fomin *- It was not advisable, but we decided to disable ERCS for a short time. I cannot say how it happened.*

(Dyatlov smiles).

The expert *- Why was the program developed by Metlenko - the chief engineer of "Dontekhenergo" test team?*

(Dyatlov smiles)

Fomin *- Naturally, it would be better to have a program developed by an expert in NPP technologies.*

The expert *- You said that the program repeated the program of 1984. Is it correct?*

Fomin *- That is why we did not agree the program with all the parties, as it had already proved its safety.*

The expert *- All the experiments failed but you nevertheless signed the Technical Solution of October 31, 1985 on commissioning of the rundown unit.*

Fomin *- We just needed to check the period of time of operation of the feedwater pumps by rundown power.*

The expert *- Why then, had you disabled the technological safety systems?*

Fomin *- It is difficult to say, several versions may be suggested.*

The expert *- As you think, why the reactor's power was reduced to 200 MW instead of 700 MW?*

Fomin *- I think that the personnel intuitively assumed that a lower power is safer.*

The expert *- But in the course of discussion of the power level, Dyatlov required 200 MW, while Kryat - a specialist in physics - strongly insisted on 700 MW. Did you know about that?*

Fomin *- Yes.*

The expert *- Did you know that in the morning of April 25, the reactivity margin was lower than 15 rods?*

Fomin *- Kryat knew that the reactivity margin was lower than 15 rods, but the NPP CSM did not tell me that on the morning operational briefing of April 25.*

The expert *- Why were the physicists estranged from the program?*

Fomin *- In that case, it was not a trip on pumps, that necessitates involvement of a representative of the Nuclear Safety Dept., but activation of an additional pump. Besides that, the deputy Chief Engineer on operational matters is a professional physicist himself. In addition, a representative of Nuclear Safety Dept. participated in the operational briefing at 11 a.m. on April 25 and he knew about the test. They knew that the test was to be conducted, that the reactivity margin is lower than 15 rods, but nevertheless they did not provide a specialist to consult the CRCE.*

The expert *- Do not you think that the specific features of the reactor manifested themselves after the accident? Did not you know about them before?*

Fomin *- I think that the safety measures that have been introduced now suggest that the reactor had some design flaws. Besides that, the void effect was assumed to be negative but it was positive in all cases.*

The expert *- Were there positive reactivity peaks at the Chernobyl NPP in the case of massive insertion of safety rods?*

Fomin *- No. Some information was available on Smolensk and Kursk NPPs.*

The expert *- Did you read the book of Emelyanov and Dollezhal on RBMK?*

Fomin *- I read it.*

The expert *- Before the accident the reactor's power often exceeded 3400 MW, GAEN prescriptions refer to that. What could you attribute it to?*

Fomin *- There were some contradictions between data of PRIZMA[17], SFKR[18] and the heat balance. Simonov provided some critical comments on the matter.*

Expert Martynovchenko *- Simonov's protocol focuses predominantly on cases of deviation from the Technological Regulations. You took them formally. Why?*

Fomin *- I do not recall cases of systematic deviations from the Technological Regulations at the Chernobyl NPP.*

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[17] A computer program for estimation of unit technological parameters

[18] The system of physical power distribution control

Martynovchenko *- One protocol on matters of the unit's shutdown specifies that the reactor was shut down according to a GAEN prescription. How do you think, is the reason serious?*

Fomin *- Yes.*

The expert *- When had you got information that the active core is destroyed?*

Fomin *- In the afternoon of April 26 when I inspected the NPP site and saw graphite.*

The expert *- The chief of RS-2 reported to you at 10 a.m. that there was no need to supply water, as the reactor was destroyed.*

Fomin *- He did not tell me that. Sitnikov said that there were separate destructions.*

The expert *- According to Civil Defence arrangements you are the commander of specialised formations. In the morning of April 26, there were 600 persons from these formations present at the NPP. What was the need to call them in?*

Fomin *- I did not control the process. Chief managers of NPP sections themselves called in the personnel they needed.*

The expert *- Who allowed to conduct the shift change?*

Fomin *- I allowed, at the NPP CSM request.*

The presiding judge - *Do the defence or the victims have any questions?*

Lyutov M.A. *- (the deputy Chief Engineer on science springs out to the rostrum) - I did not know, I did not know about the program! They said I knew, but I did not!*

The presiding judge *- Do you have questions to Fomin?*

Lyutov *- No.*

The presiding judge *- Then, sit please, this is not a question. We will interrogate you later.*

Fomin's defender *- Did Lyutov know that the tests were to be conducted?*

Fomin *- He knew.*

Fomin's defender *- Did he know that the unit was to be shut down?*

Fomin *- He knew.*

Fomin's defender *- You said that he self-alienated. How was it manifested?*

Fomin *- He had to ensure presence of his specialists.*

Fomin's defender *- Do you have any doubts about Dyatlov, about his qualification?*

Fomin *- No, he is an experienced specialist, an engineer-physicist.*

Fomin's defender *-Who was the acting Chief Engineer when you were ill for 4 months?*

Fomin *- Lyutov.*

Fomin's defender *- The program was developed when he was present, did he know about it?*

Fomin *- He knew.*

The presiding judge *- When was the draft program ready?*

Fomin *- In March.*

The presiding judge *- And the program itself?*

Fomin *- In April.*

Fomin's defender *- Why did you return to work before your complete recovery?*

Fomin *- The Director was to attend 27th CPSU Congress and the Party Committee Secretary Parashin asked me to return to work. I objected, but he said that I would not need to deal with operational issues and I assented.*

The expert *- Having only a correspondence course in physics, what did you hope for when you fulfilled duties of the NPP Chief Engineer?*

Fomin *- I did not seek to take the Chief Engineer's position. But when I was offered it I did not refuse. Besides that, I recommended the Director to appoint physicists as deputy CEs. Sitnikov, Dyatlov and Lyutov are physicists.*

Dyatlov's defender *- Do you think that the situation was normal when Dyatlov alone managed all works at Unit 4 for two days?*

Fomin *- He had breaks. We contacted by phone. On April 25 he had a rest from 4 p.m. to 11 p.m..*

Kovalenko's defender *- Why Kovalenko drafted his own job description himself? Does it contradict to the Personnel Management Guidelines?*

Fomin *- I cannot say, I did not read (verbatim - N.K.).*

Kovalenko's defender *- Was Kovalenko obliged to participate in the rundown program?*

Fomin *- Yes.*

Kovalenko's defender *- Why was not he mentioned in the program?*

Fomin *- As he is a section chief manager, he cannot be authorised to fulfil operational functions. But he could control work of his specialists under the program.*

Kovalenko's defender *- Did you conduct a meeting on the program?*

Fomin *- I did not conduct it, Dyatlov did.*

Kovalenko's defender *- What prescribes a mandatory presence of Kovalenko in the course of the tests?*

Fomin *- Nothing prescribes that.*

Rogozhkin's defender *- What would you do if, in the morning of April 25, you would be provided information by the NPP CSM that the reactivity margin is lower than 15 rods?*

Fomin *- I would shut the reactor down.*

Rogozhkin's defender *- Where is the NPP CSM workplace?*

Fomin *- In the CCR or UCR. He himself decides where to stay.*

Rogozhkin's defender *- Who had informed you on the accident?*

Fomin *- I was told by NPP CSM Rogozhkin, at about 4 a.m..*

Laushkin's defender *- Did Laushkin know about the program?*

Fomin *- I do not know.*

Laushkin's defender *- and about the rundown?*

Fomin *- I do not know. He knew that the Unit was to be shut down.*

Laushkin's defender *- Did Laushkin submit his prescriptions to you?*

Fomin *- No.*

Laushkin's defender *- and to the NPP director?*

Fomin *- I do not know. Elagina and Frolovskiy submitted, as well as Shevchenko.*

Laushkin's defender *- You said that Lyutov participated in the operational briefing. What was his failure to act?*

Fomin *- He did not arrange presence of on-duty physicists on April 26 and did not report on the reactivity margin decrease.*

The presiding judge *- Tell us please, what is the education of the chief inspector engineer on technical operation rules A. Nazarkovskiy?*

Fomin *- Secondary technical.*

The presiding judge *- Could a person with such an education investigate accidents at the NPP with the due quality?*

Fomin *- I always remembered about the problem and looked for a replacement of Nazarkovskiy. Unfortunately, I failed to do it timely.*

9. 07. 87

Session # 3, from 9:00 to 12:30

The presiding judge *- Defendant* ***Fomin****, tomorrow we had a detailed discussion on deviations from the safety rules in the program itself and in its execution. How could you - as the Chief Engineer - explain these deviations?*

Fomin *- The program was designed to make the test representative.*

The presiding judge *- The question deals with other matters. How could your deputy Dyatlov allow the deviations that resulted in the accident?*

Fomin *- Dyatlov is an experienced specialist, he has 9 years of practical experience at the Chernobyl NPP and he knows his duties well. I knew Akimov as a professional, careful specialist. I observed his work when I was a deputy CE. CRCE Toptunov was not very experienced, he did not have skills for operating in transient modes.*

The presiding judge *- You do not answer to the point. How could you explain deviations from the safety rules made by your personnel?*

Fomin *- Without having the testimony of Akimov, I think that it was mainly due to deputy CE Dyatlov's costiveness.*

The presiding judge *- You read the testimony of Akimov. Who made the key deviations?*

Fomin *- The key deviations were made according to orders of Dyatlov.*

The presiding judge *- How do you think, why did Dyatlov venture on that?*

Fomin *- Maybe, Dyatlov and Akimov focused predominantly on the distribution of the power density radially and by height, while overlooking the reactivity margin in the transient mode. In such a way I could explain actions of people who participated in the test.*

The prosecutor *- Who had appointed the people who participated in the program?*

Fomin *- The one who had approved the program.*

The assistant prosecutor *- Who had approved Dyatlov as the test manager?*

Fomin *- I had approved Dyatlov as the manager in charge.*

The prosecutor *- You said that the late Toptunov was a young specialist and lacked experience. How could you appoint him for participation in such a complex test?*

Fomin *- It was not easy to foresee who would took part in the test. The test was rescheduled to the second shift only due to problems at the South Ukrainian NPP.*

The prosecutor *- What was an average level of professional skills of the NPP personnel? GAEN many times noted insufficient training of the personnel, lack of training simulators. You were regularly issued their protocols but dealt with them in a formal manner.*

Fomin *- If I got information on cases of non-compliance with the technology discipline, I reviewed and terminated them. But people are mere human and new violations happened.*

The prosecutor *- In the course of the pre-trial investigation witnesses admitted that training at the Chernobyl NPP was formal. It was not efficient enough.*

Fomin *- We regularly conducted professional contests and people demonstrated high professional achievements.*

The prosecutor *- Contests may demonstrate everything, a few skilled persons may be found. I am interested in the main body of the personnel. Why did not you have a training and methodological council at the NPP?*

Fomin *- It was my fault.*

The prosecutor *- And whose also it the guilt?*

Fomin *- The Director's.*

The prosecutor *- As for Toptunov - you said that in his case, his ignorance prevailed. But what prevailed in the case of others - was it ignorance or a neglect?*

Fomin *- It was rather neglect due to excessive knowledge.*

(Fomin behaves more confidently and vigorously than he was yesterday. His voice sounds familiar - N.K.).

Fomin *- I was convinced that the Chernobyl NPP personnel are disciplined, qualified and educated. It was clear in comparison with other NPPs. I was sure that the collective was stable.*

The presiding judge *- Let us do not compare with other plants. You had 39 personnel-associated violations. Is it a small figure?*

Fomin *- The figure covers the whole 5-years period and all the NPP units. I think that it was a small number of violations at Unit 4.*

The prosecutor *- Unfortunately, you understand the issue incorrectly, even now, after all the things that happened.*

The prosecutor *- When did you arrive at the NPP on April 26?*

Fomin *- It is hard to say, I do not remember a precise time. It was a few minutes past 4 a.m.*

The prosecutor *- Did not Vorobyov reported the radiation situation in your presence?*

Fomin *- There were no Vorobyov's reports in my presence.*

The prosecutor *- Where did you stay on April 26?*

Fomin *- In CCR, in Unit 4 CR, in the bunker, in my office, I went to Pripyat.*

The prosecutor *- Were you with Bryukhanov? Were you alone or with other specialists?*

Fomin *- I was not alone, I was with people.*

The prosecutor *- How, then, could you have no information on the radiation situation, when you were with people who permanently discussed radiation doses? Your answers are hardly convincing.*

Fomin *- I really knew nothing about high radiation doses. There were no fire-affected personnel at the reactor unit at that time. Besides that, I had a lot of tasks to fulfil, including the ones ordered by the Moscow commission.*

The prosecutor *- By 4 a.m. nobody from the commission had arrived. Your people reported, provided information. Your people with burns were transported to the medical facility. Were not you interested in these matters?*

Fomin *- I was interested. But I arrived in the bunker before the shift change. In that morning many things were unclear to me. And not to me only, but to the representatives of the Chief Designer and "Gidroproekt". It was before I saw graphite elements at the NPP site in the afternoon.*

The prosecutor *- The Supreme Court can hardly believe that, staying permanently at the NPP site, you had no idea about the scale of the accident and its severity. When did you leave the NPP?*

Fomin *- Practically I lived at the NPP site up to May 1, I rested in the ventilation chamber of the Civil Defence bunker.*

The prosecutor *- It is even more incomprehensible, how you managed to remain unaware being with people who knew the situation.*

A peoples assessor *- Fomin, why the NPP top officials and the personnel nurtured the carelessness that resulted in the accident?*

Fomin *- In the course of regular meetings with the personnel, both positive and negative aspects of the NPP operations were highlighted. Attention was attracted to negative aspects of the personnel operations.*

The presiding judge *- Are there any questions to Fomin? Sit down please.*

The presiding judge *-* ***Defendant Dyatlov****, what would you like to tell the court?*

Dyatlov A.S. *- I was appointed to the Chernobyl NPP as the deputy chief of RS and worked on that position until 1979. Then I was appointed the chief RS-2, and in 1983 I was appointed the deputy CE on operation matters of the second phase of the Chernobyl NPP project. My duties were mainly associated with: personnel recruitment, personnel training, processing documentation, organisation of supervision over installation works, etc. I am charged in* *insufficient control over actions of the personnel in the course of operation of the reactor unit. Now I will explain my everyday work routine.*

At 8 a.m. we had operational briefings with the NPP Director on the intercom. Then I went to the Unit. Every day, from 9 a.m. to 1 p.m. I maintained workplace control, inspected equipment and made surveys. In my work I relied on deputy chief managers of NPP sections on operations, every day we conducted operational briefings with them to discuss operational issues. Every day I always visited unit control consoles. The key equipment items were inspected not less than once in a week. At least monthly I surveyed the buildings - from basements to roofs. After the lunch (I had my meals at the end of the scheduled lunch break) I had no time to visit reactor units any more. After the lunch I processed documents, dealt with exams and personnel matters. My working day closed at 7 p.m. Saturdays did not differ. As you can see, my work style was far from being an office-centered one. In addition, I visited the NPP at nights.

By my nature, I could not leave a violation unattended. I immediately informed the personnel on the matter and demanded to remediate them. It is impossible to say that there were deviations from the Technological Regulations, that accumulated and were not remediated. There were personnel-induced SDS-1, 2 and 5 events at Unit 3 and Unit 4. These errors are immediately visible, yes, we had them, unfortunately. But we did not have concealed, unattended violations. Naturally, in comparison with 1st phase of the Chernobyl NPP project, we had less stable personnel. We had personnel turnover up to 30%, people opted to work at 3rd NPP phase.

Some people said, that I violated the occupational safety rules, the Technological Regulations, rules and norms. As I myself did not participate directly in technological operations, it could happen only through my orders. I thought about that, I had a lot of time and I have to say that I do not have such a sin. I think that it will be proved.

I approved the schedule of shut down of Unit 4 with incorporation of the "rundown" program into it. Why I did it? It was a design-stipulated solution that should be brought to a logical conclusion. Besides that, we had the Inspectorate's prescription and the program was approved by the Chief Engineer. Thus I had not reasons to refuse incorporation of the program into the schedule.

I do not think it is worth to focus on all the tests. The tests were completed successfully. There were two aspects - TS was not ready to conduct vibration tests at TG-8. Brackets for installation of sensors were not welded timely to the turbine generator # 8. The chief manager of TS Khoronzhuk and the deputy CE manager on repairs Alekseev were responsible for that. When TG-8 was made finally ready for the tests, the grid operator prohibited us to conduct the program with a variable load on the turbine generator as the program requested.

All persons, who participated in the program, and all instruments were ready in time. No delays were caused by these factors. It was a shortcoming *of the shutdown - representatives of some NPP sections were not present. Regardless of the program they had to participate in the shutdown operations.*

The program was reviewed only by the personnel who had to participate in its execution - shift personnel of Kazachkov, Tregub and Akimov. Tregub was well familiarised with the program, while Akimov reviewed it timely. All these people were instructed on the program.

We are charged that the works were conducted in a hurry, with combined work operations and at night. I can state that there were no combined work operations, no haste. There are testimonies of Kabanov (KhTP), that they measured vibration in the process of rundown. But their measurements could not affect the reactor in any way. Apparently, it was impossible to make the necessary conclusions for alignment and balancing purposes at the base of these measurements. Therefore, when he reported me that the vibration measurements were completed, I ordered him to make preparations to the rundown program. At that moment the deputy TS chief manager Davletbayev approached me and said that KhTP representatives ask to conduct vibration measurements at a free rundown. I said him: "No. We shut the reactor down according to the rundown program, but if we will have enough steam, you may launch the turbine and measure". So, there are no grounds to say about haste or works' overlaps. As for the night time - it was a decision of the grid.

I am charged in commissioning the rundown unit without its full-scale testing. However, first, the tests in the no-load mode were conducted successfully. After the tests, the Chief Engineer issued the Technical Solution, on commissioning of the rundown unit with subsequent final testing.

Another aspect - I am charged in supposedly signing the program without its reviewing in depth first. When Metlenko approached me on the matter in 1986, we discussed the program in detail so far as it concerned electric matters. Then I told him to contact CCF, RS and TICS for adjustments and signature. I discussed only electric matters with him, as it was not of any use to discuss the rest with him. I myself analysed technological aspects, as I though that I have a sufficient knowledge to do it. I thought out the sequence of the program completion in advance, no doubts may arise in this connection.

As for the equipment vibration - no vibrations were registered when Main Circulation Pumps were stopped (and I observed hundreds of their stops). 18 Hz vibration is present - twice lower than the rundown frequency (35 Hz).

After agreeing the program with the NPP sections, we gathered once again in my office and discussed it in detail once more. Then Metlenko - maybe - handed it to Fomin for approval, but I do not know for sure.

***The presiding judge** - Fomin, how did you receive the program?*

***Fomin** - As usual, via the internal documents' turnover.*

***The presiding judge** - A break for 15 minutes.*

(break from 12:30 to 12:45)

The presiding judge *-* ***Dyatlov****, please continue.*

Dyatlov *- There are no documents that prohibit operating 4 MCPs per side. Moreover, the arrangement is often used, for example in the case of a trip on MCPs. Otherwise, it would be a subject of some limitations. MFCC [multipass forced circulation circuit] flow rates are not limited by any guideline documents, limitations are set only for flow rates though TCs. There were no alarm signals of pre-set threshold values reached, low flow rates or excessively high flow rates after activation of MCPs, therefore, there were no reasons to switch the fourth main circulation pump on. When pumps are working in parallel and are powered from sources with different frequencies, it is necessary to check for potential multiple activation of reverse valves. MFCC responds to pressure only, to flow velocity head that declines in the case of pumps powered by the rundown. Besides that, MCPs are connected to the SDS activating at flow rates over 5000 m^3/h. Under 5000 m^3/h, reverse valves will not work. So, at flow rate of 5000 m^3/h, the SDS disconnects the pump and it stops as usual.*

In the course of the program execution we did not reach such a flows rate. All flow rates were lower than 5000 m^3/h. Therefore, there are no reasons to suggest that it could result in hydraulic instability.

And now, why we had chosen to disable ERCS.

1. *According to the design, ERCS is intended to cool the active core in the case of a MCA, that was assumed by the designers to have the annual probability of 10^{-6} event per reactor. Should we disable ERCS for 12 hours, then the annual probability of a MCA in this period of time would reach 10^{-9} event per unit. The probability is extremely low.*
2. *Besides that, the Operation Rules allow (§29, 29À) to operate the reactor on power without ERCS, if ordered by the Chief NPP Engineer. In the case of connection of the MCA button it would be difficult to account for all potential problems in the by-pass circuit or for human errors and we were anxious about a potential injection of cold water into a hot reactor. Were our concerns substantiated? Yes. The new list of accident-initiating events refers to an unauthorised activation of ERCS. I considered these reasons sufficient to disable ERCS.*

And now, as for the MCA button. It was said that no documentation was provided on the button. The button was a temporary one, terminals were specified to connect it to. Besides that, there is no sense to discuss the MCA button when the ERCS itself was disabled.

As for the program - it was said that the safety measures were insufficient. This is not correct.

First, the program itself is a safety measure. It is the program that defines what to do and how to do it safely. The experts criticised the program for failing to stipulate presence of the Nuclear Safety Dept. in the course of a trip on MCPs. This is not the case. The experts did not read para 19.4.1 of RBMK Control Manual fully. The para suggests that the procedure (the one with involvement *of the Nuclear Safety Dept.) remains in force until a special authorisation. The authorisation was issued. The formalities were fulfilled.*

As for MCPs - the lower is the reactor's power, the lower reactivity effect will activation of the main circulation pumps induce. SFKR recorder tape shows that. It was said that para 16.2 NSR was violated. The paragraph states that in the case of trips for technological purposes, it is necessary to provide for reactivity compensation by automatic means or manually. Activation of MCPs did not result in reactivity changes. Neither MCPs were switched off. They switched off when the reactor was already destroyed.

And now, as for steam. In this connection nobody had any questions, neither prior to the TG switching off, nor before it. No catastrophic pressure increases were observed up to the completion of the tests.

A little bit more about the program - any program entails deviations from one guideline document or another. However, it is necessary to assess whether the deviations are necessary and possible. Otherwise, everything could be made without a program. It is the TP Dept. that is responsible for agreeing a program with other organisations (GAEN, NIKIET, etc.) and for its due processing. We have the Administrative Office to register programs, but the TP Dept. is a department staffed by specialists. At the Chernobyl NPP, procedures were in force, regulating who should apply to whom and on what matters. Besides that, I personally said to the Chief Engineer in his office that the program was not agreed with the superior organisations. The Chief Engineer did not respond.

And now, as for the reactor shut down. Yes, the reactor was shut down with some delay. As Akimov is dead, we will not be able to ascertain why he delayed the shut down. But it did not affect the causes of the accident (verbatim - N.K.). It was said that we could not disable SDS-5 on stop of two TGs. But it was made in compliance with the Technological Regulations and did not affect the accident's development. At a power level under 100 MW (electric) the SDS should be disabled. Therefore, it is not a deviation from the Regulations.

The disabled ERCS did not affect the course of the accident and its causes. First, ERCS is not designed for such an accident. Second, it could not be activated anyway as no MCA signal was generated. Without the signal, the operator would not activate it manually as he would have no reason to. Third, the gas tank ERCS was destroyed in the initial seconds of the explosion, and all ERCS electric valves were off power. When I approached safety panels at the Unit control console, all three panels were dead. I do not know why.

And now as for the reactivity margin. The Chief Engineer authorised operation with reactivity margin under 26 OCRs. Starting from 24:00, ORM did not reach 26 OCRs or above, so there were no reasons to apply for a new authorisation.

As for the poison override - I was not present in the Unit Control Room in the course of power fall. I surveyed the Unit at that time. In such moments (unit shutdown) different defects are usually revealed so I always conduct inspections.

But I remember that Toptunov, Akimov, Proskuryakov and Kudryavtsev were nearby the CRCE console. Akimov said that power decreased to 30 MW. When I came, it reached 50 -70 MW and I did not prohibit them to raise the power. According to the chart, the expert claim that the reactor power was zero for three to four minutes (Martynovchenko). At the same time, there is the testimony of Toptunov who insists that power lower than 30 MW was not observed. I think that Martynovchenko does not have reasons for such a conclusion. No deviations from the Regulations were made in these operations.

Once more about disabling SDS-5 on disconnection of two turbine generators. If the Unit electric power decreases under 100 MW (electric), the SDS may be disabled without authorisation. So, Akimov disabled it, without asking me on the matter. I did not instruct him to do it.

All the safety systems that were disabled, had to be disabled, for example, the SDS on reduction of water level in the separator up to minus 600 mm. It just was not switched from SDS-1 to SDS-5 (as prescribed) in the course of power reduction. However, the SDS on water level of minus 1200 mm was enabled, as well as SDS on other sensors. Therefore, the shift personnel did not disable anything extra. All the safety systems met the Regulations.

I am charged in instructing Akimov to reduce the reactor's power from 760 MW (the power level by 24:00) to 200 MW, that resulted in initiation of poisoning processes and in decrease of the reactivity margin under 15 OCRs. I did not instruct Akimov to do it. Asimov's testimony does not confirm it. Tregub's testimony suggest it. I think that we will be able to ascertain these things in the course of the court review.

I do not blame Toptunov for the power fall to 30 MW by no means. Any operator could do it while switching from one regulator to another, to a greater or lesser extent. Besides that, the regulator, he switched to was faulty. After the power fall, Akimov himself proposed to increase the power up to 200 MW, while the program stipulated 700 MW. The tests were almost completed and knowing the reactivity margin value by 24:00, I decided to rise the power to 200 MW only.

I am charged in failing to take measures for the reactor's shutdown in the course of disconnection of TG-8. I did not see that the reactor had not been shut down. I was at the distance of about 10 m from the CRCE console.

I did not feel any overconfidence in dealing with reactors. I did not assume that there are important and not so important reactors-related aspects. I consider all these aspects important. I always worked in such a way. Prior to my work at the Chernobyl NPP, I managed assembling, testing and commissioning works with more than 40 active cores. At the Chernobyl NPP I took part in launch of Units 1, 2, 3 and 4. I did not fear to work at a reactor. But I have never dealt with reactors in an overconfident manner.

We distributed our functions in the course of the TG disconnection as follows:

- *Kirshenbaum - disconnects the TG;*

- *Akimov - observes the launch of the diesel-powered generator and orders Toptunov to shut the reactor down;*
- *Gazing and Tregub stand nearby the TG control console;*
- *Proskuryakov and Kudryavtsev stand nearby Toptunov;*
- *I stand nearby the TG instruments.*

We disconnected the TG. Everything was quiet, as usual. Then I heard a conversation and turned - Toptunov told something to Akimov. I did not hear what Toptunov said. Akimov said - shut down the reactor. But as I think Toptunov said to him - the automatic regulator reached the terminal switch. There is nothing unusual and dangerous in that. And Akimov said - shut down the reactor. I mentally recalculated frequency of 35 Hz into rotations. Then the first stroke happened. It was followed by the second and heavier stroke. It was a prolonged one, or there were two strokes that merged into one.

(break from 14 to 15)

Dyatlov *(continues) - As I already said, 1 - 2 seconds later, the second stroke happened, more intensive than the first one. Initially, I thought that something happened with deaerators. I immediately thought that as they are installed above the Unit Control Room, hot water might soon gush down into the room. I immediately ordered to move to the Reserve Control Room. But when the dust settled and coating plates fell from the ceiling, I reversed the order. We turned to the control instruments. The situation was grave. All 8 main safety valves were open. No water level was registered in the separator. The SDS rods entered the active core to the depth of not more than 4 metres. I ordered Akimov to launch two additional diesels, and all MCPs at the both sides. As all electric valves were deenergised, I send the chief RS shift manager Perevozchenko to open at least 1 valve at each side. He soon returned and said that pump outlet valves were open but water could not be supplied to MFCC, as the gas tank ERCS was destroyed (MFCC valves were installed there).*

I came to the CRCE console. SFKR power was zero, CSS cameras also reported zero power. The reactimeter reported some fluctuating positive values. Control and SDS rods were mainly inserted to the level of about 4 m. At that time I still did not know what had happened but I realised that the accident was very serious. I went to the Central Reactor Room and reached the corridor. It was filled by dust and smoke. I returned, said to switch ventilators on to remove smoke and moved to the Turbine Room Building. In ordinary terms, the situation in the Turbine Room was horrible. In technical terms, streams of hot water flushed out at the level +5.6 m from feedwater electric pumps, sparks of short circuits were visible nearly the pump control console. I went farther. A roof plate cut the oil pipe of TG-7 and the oil (about 100 tons) escaped to the Turbine Room. The TS personnel and Davletbayev were already there. A decision was immediately made to drain the oil to the emergency collector tank.

Then I went to the Unit Control Room. In the initial minutes I realised that fuel assemblies were lost, were destroyed. A little bit later I understood that the reactor was destroyed too, and lost completely. It was impossible to reach the Central Reactor Room due to debris. People tried to reach it, but fortunately they failed - otherwise all of them would die. I that time I thought that construction "E" was lifted up, breaking the expansion joints, and then it returned to its place. I thought so.

When I again went to the corridor, the smoke was not so dense as earlier, notwithstanding that just a short time elapsed. In the corridor I saw Kurguz who was burned by hot water. I said the people who accompanied him to go to A&UB-2, the ambulance was to arrive there.

When I returned to the Control Room, I immediately said Akimov to call firefigthers in full force and he did it.

I went to the open and went round the Unit. I saw destruction, fires on the roofs and the destroyed ERCS. I approached Unit 3, fire engines were already present there. However, they reached Unit 3 Control Room. I asked who is in command and they pointed to Pravik. I showed him the collector tank of empty fire hydrant pipes to the roof of Unit 4.

I went to Unit 3 Control Room through Unit 3 building. With the Unit chief shift manager Bagdasarov we checked whether there were some obstacles that interfere with the Unit operation. At the base of initial check they said me that there were no reasons to shut the reactor down.

I went to Unit 4 Control Room and called the deputy ES chief manager Lelechenko in. I told him and Akimov to kill power supply to the machinery, except the absolutely necessary equipment items. The 6 KV board was out of danger.

The order was issued to replace hydrogen from turbine generators.

As there were fires on the roof, I went to the open again and went round the Unit one more time. Fires were not eliminated yet. Then I went to Unit 3 and ordered to shut the reactor down. The Unit chief shift manager Bagdasarov said that the Unit operates without problems and made a phone call to chief NPP shift manager. He said the Unit shutdown should be agreed with Bryukhanov. But I said to shut it down immediately.

***The presiding judge** - Your account exceeds the limits of the charges. Do you think that it is necessary to tell us all that?*

***Dyatlov** - Yes, it is associated with the last part of the indictment.*

At some time, the chief shift manager of the Occupational Safety Dept. Samoilenko came to Unit 4 Control Room. In the central part of the Control Room the instrument with the upper margin of 1500 μR/sec (54 mSv/hour) went off-scale, while closer to walls radiation levels reached 400 (14 mSv/hour). I thought, that is was advisable to move to the Reserve Control Room. We measured radiation levels there. The windows were broken, as a result, the radiation level there exceeded 1500 μR/sec (54 mSv/hour). I immediately started to remove excessive personnel - teams of Metlenko and Kabanov. I *removed Kirshenbaum and Toptunov. I left Stolyuarchuk and Akimov there. Perevozchenko reported that Khodemchuk and two operators of the Central Reactor Room were missing, but the latter two were found quickly - they accompanied Kurguz out. We started to search for Khodemchuk. We did not see him in the MCPs compartment. One MCP was collapsed by a crane that fell on it. Perevozchenko on the beam reached to the door of room # 435, blocked by debris (the room of MCPs). He was accompanied by Yuvchenko and a radiation monitor, but he made measurements and departed. They could not open the door. Perevozchenko shouted, but nobody replied from behind the door.*

As for the dose monitoring. Radiation monitor Gorbachenko was out of operation immediately, as he assisted in taking Shashenok out. The second radiation monitor stayed at the radiation monitoring console. It was impossible to distribute the third radiation monitor between all places where the monitoring was needed. It was clear for me that we could not make anything by our own means. We only make efforts to prevent new fires and tried to find people.

***The presiding judge** - We are interested in information associated with your indictment.*

***Dyatlov** - There were the following violations: in two to three MCPs water flow rates exceeded 7000 m³/hour, as set by the cavitation margin. There violations had no consequences, as it was objectively confirmed. Should cavitation emerge, it would have resulted in reduction of flow rates through the pump, that would be registered by the teleprinter.*

As for the delay in activation of SDS-5 button. Should we activate the button earlier, the explosion would have happened earlier. In other words, the explosion was caused by the state of the reactor. I ordered to stop raising the reactor's power at the level of 200 MW, as I though that the reactor meets the due safety standards of the USSR, and corresponds to the documentation, issued to the Unit Control Room by the Nuclear Safety Dept. I considered the power reactivity effect negative. Therefore, we were not expected to lose reactivity in the course of power reduction. While reducing power from 700 to 200 MW we could lose not more than 1.5 OCRs due to poisoning. And my assumptions were correct. By the moment of activation of the SDS button, the operational reactivity margin was neither 1.9, nor 6.4, it reached at least 11 rods. Instead of shutting the reactor down the button worked as a fuse. And all further developments were defined by the positive power reactivity effect, that according to NIKIET is always negative. That is all.

***The prosecutor** - Why was it necessary to issue the order on introduction of the rundown unit? What is the sense of that?*

***Dyatlov** - Surely, there was some sense. First, in the no-load mode, the tests were completed successfully. And second, there was a Technical Solution of the Chief Engineer of the NPP and I complied with it.*

The prosecutor *- Did you admit that an entry on shut down of the reactor should be incorporated into the program?*

Dyatlov *- Yes.*

The prosecutor *- But the program did not instruct to disable SDS.*

Dyatlov *- Yes. But the situation necessitated it. Besides that, the rules allow that.*

The prosecutor *- You exceeded the sphere of your competence on a range of issues. There are the deputy CE on science, the Nuclear Safety Dept. Why did not you agree your actions with them?*

Dyatlov *- Lyutov's position is of the same level as mine, as a result, the NPP CE had to decide whether I should agree my actions with him.*

The prosecutor *- Why did you agree to conduct the experiment without agreeing its programs with the Scientific Supervisor, the Chief Designer, etc.?*

Dyatlov *- The NPP CE and the TP Dept. had to ensure that.*

The prosecutor *- As for the MCA button. It was your independent action. The button, at least, should have been agreed? I am referring to formal aspects.*

Dyatlov *- I cannot add anything to what I have already said.*

The prosecutor *- Well. You remember Kryat's testimony. In the course of the meeting in your place, before the program's launch, he flatly required to maintain power at the level of 700 MW, not 200 MW.*

Dyatlov *- I remember Kryat's testimony, but Kryat did not participate in the meeting. Kryat could say that to Borets, while I could stand nearby and communicate with other people.*

The presiding judge *- Dyatlov, please reply briefly and to the point.*

Dyatlov *- I did not have a conversation with Kryat on these matters on April 22.*

The prosecutor *- Did you know that on April 25 the reactivity margin was lower that 15 OCRs?*

Dyatlov *- I did not know about that up to 12 - 13. But, as the Chief Engineer had not issued an instruction to shut down the reactor due to these reasons, I assumed that the works could continue.*

The prosecutor *- Fomin, did you instruct Dyatlov to operate with ORM lower than 15 OCRs?*

Fomin *- I did not issue such an instruction.*

Dyatlov *- There are testimonies of Kovalenko and Fomin in the case file materials.*

The prosecutor *- Well, I know what Kovalenko said, I withdraw the question so far.*

The prosecutor *- On April 26, at 1:23 a.m. the reactivity margin reached 8 rods. Why was not the reactor shut down?*

Dyatlov *- The reactivity margin by 1:23:30 could be found 5 minutes later (verbatim - N.K.).*

The prosecutor *- Why was it so urgent? The Centralised Control System could provide information on the reactivity margin, why did not you wait?*

Dyatlov *- You do not listen to me, interrupt me. Reactivity margin data are requested by the CRCE or by the chief Unit shift manager. I do not belong to the operational personnel, I do not have access to keys.*

The prosecutor *- When you saw that the reactor's power was 30 MW, why did you allow to rise the power, why did not you order to shut down it?*

Dyatlov *- Power decrease to 30 MW is not a shutdown, it is a partial power reduction. An operational automatic regulator may switch to automatic control mode even at 30 MW. So I did not order to shutdown.*

An expert *- Why the power decrease happened? Was it a SDS activation or a power fall?*

Dyatlov *- It was not ascertained. The CRCE made an entry - a short SDS activation by rate of power growth. But the teleprinter and DREG did not register that. I was not present in the Control Room when it happened, I did now see the alarms.*

The expert *- When had you requested the reactivity margin data for the last time?*

Dyatlov *- I asked CRCE at about 1 a.m. He answered - 18 or 19 rods. I do not remember the precise figure. But it corresponded with the value I expected.*

The expert *- Had all the operators reported their readiness to you before you started to execute the rundown?*

Dyatlov *- Only that way.*

The expert *- Did you know the unit chief control engineer's parameters?*

Dyatlov *- Mainly yes, everything was normal with six MCPs. Akimov reported me everything.*

The expert *- Did you see the DREG printouts, how did MCPs operate in the course of rundown?*

Dyatlov *- I saw charts, produced at the base of DREG printouts.*

The expert *- How did they operate?*

Dyatlov *- Normally. Flow rates through MCPs fluctuated normally for Unit 4. We had fluctuation of flow rates at Unit 4. MCP flow was stable, as in the case of other units, while flow rates parameters fluctuated up to 5% in the course of normal operation. I instructed the deputy chief of TICS to check pulse tubes.*

The expert *- You said that prior to the Unit shutdown, the automatic regulator reached the terminator switch. What could it be attributed to?*

Dyatlov *- In one minute before the shutdown, the feedwater flow reached about 700 tons per hour per side. Then, CUCE reduced it to 250 t/h for the both sides. That introduced some positive reactivity. Besides that, the flow rate through MFCC was somehow decreased due to rundown of MCPs. That also added some positive reactivity.*

The expert *- So, the reactor runaway was caused by these factors?*

Dyatlov *- By no means. Power changed in such a way it usually changes in the case of operating automatic power regulator.*

The expert *- Do you agree that the reactivity margin increased?*

Dyatlov *- Yes, but the magnitude of reactivity was surely lower than the regulator's capacity to reduce it.*

The expert *- What were the abnormal manifestations after activation of the SDS-5 button?*

Dyatlov *- No manifestations were observed. Metlenko disconnected the TG after the first stroke.*

The expert *- Let us return to the conversation of Akimov and Toptunov. Everyone knew that the reactor should be shut down prior to disconnecting TG. You heard that Akimov said to the CRCE - shut down the reactor! Does that mean that it was not shut down?*

Dyatlov *- Yes, and I noticed that.*

The expert *- As for combining work operations - the vibration measurements and the rundown - what could you say?*

Dyatlov *- The Mercedes-Benz instrument allows to measure vibration almost in no time. No special conditions are needed, you may use any pause.*

The expert *- Does the decrease of reactor's power from 200 to 30 MW reduce or increase the reactivity margin? I ask for your knowledge as a physicist.*

Dyatlov *- If power effect is positive, the reactivity margin will decrease. If power effect is negative it will grow.*

The expert *- Are there other effects as well?*

Dyatlov *- (he told about pressure effects in the separator, poisoning, changes in graphite temperatures). It is necessary to look at quick effects only.*

The expert *- What components does the power effect include?*

Dyatlov *- Which one? Quick or full?*

The expert *- Full!*

Dyatlov *- Is there a physics exam? I will ask you to answer the question!*

The presiding judge *- Dyatlov, where are your manners? If you do not want to answer the question, just say that to the court.*

Dyatlov *- OK.*

Expert Martynovchenko *-In 1986, you have not registered any inspection rounds in the log.*

Dyatlov *- The log of night inspection rounds is stored in the NPP Control Room. Daytime inspection rounds are not registered in the special log. Records are made in operational logs.*

Expert Martynovchenko *- Do you think, that you worked in compliance with the Guidelines?*

Dyatlov *- Yes.*

The presiding judge *- Who had instructed and whom before the launch of the program?*

Dyatlov *- (provided a very detailed account - N.K.).*

Expert Martynovchenko *- Why was it necessary to disable safety systems, and then shut the reactor down manually? Why were these complications made?*

Dyatlov *- Akimov apparently feared the safety system activation due to declining pressure in separator in the course of the reactor's power reduction. And then, he could forget to switch it on again. He did not approach me on the matter. I did not know that the security systems are disabled.*

The expert *- Was the NPP CE aware of the works being conducted?*

Dyatlov *- He knew.*

The expert *- Did you agree the deviations from the program with him?*

Dyatlov *- As for the reactor power increase to 200 MW instead of 700 MW - I did not agree it with him.*

The expert *- What had you reported to the NPP CE on April 26?*

Dyatlov *-I did not see him on April 26.*

The expert *- and to the Director?*

Dyatlov *- I handed him 4 charts from the Unit's control instruments and said that a wrong reaction of SDS happened.*

The expert *- Why did you retain people in the Unit Control Room after the accident?*

Dyatlov *- I retained the minimal number of personnel there. Besides that, according to my job description I had to do it to prevent a higher radiation exposure (verbatim - N.K.). I knew that radiation exposure doses were high there but I had no idea that they are mortally high. Should I fail to retain people to prevent fires, I am sure that all firefighters of Ukraine would have failed to extinguish them.*

The expert *- Did you see graphite in the open?*

Dyatlov *- I made two walks around the Unit, at 1:40 and at a few minutes past 2. I did not see graphite. It was dark there.*

The expert *- But Vorobyov saw graphite near the canteen on April 26, at 3 a.m. when it was also dark.*

Dyatlov *- I was not near the canteen.*

(The expert asked several question on hydraulics, Dyatlov answered them).

The expert *- At what power levels is the void effect higher?*

Dyatlov *- The void effect is higher at lower power.*

The expert *- You were responsible for the rundown program but in the critical moments you were far away from focal points. How could you explain that?*

Dyatlov *- When, specifically?*

The expert *- When the reactor power fell.*

Dyatlov *- At that time, the turbine vibration measurements were conducted. I was there. At that time, no works were made in the Unit Control Room.*

The expert *- You are interpreting documents (the Regulations, etc.) in your own way. You decided to stop (after the power fall) at the level of 200 MW instead of 700. Why?*

Dyatlov *- Yes. As the As the chief manager of the tests I had powers to adjust conditions somehow but within the limits as set in the Regulations. And the power level of 200 MW is within the regulatory limits.*

The expert *- However, at the level of 700 MW the reactor could be better controlled that at 200 MW. How do you think?*

Dyatlov *- The power of 200 MW is within the regulatory standards. We controlled it by all standard systems.*

The expert *- Did you know the distribution of the power density field?*

Dyatlov *- Yes, I knew.*

Kudryavtseva *(the widow of A.Kudryavtsev, the back-up CRCE who died from the acute radiation sickness) - Dyatlov said that Kudryavtsev and Proskuryakov quickly returned from the Central Reactor Room (as Dyatlov said earlier, they did not reach the Central Room). What, then did they do up to 4:30?*

Dyatlov *- I did not instruct them to do anything more. I instructed only the chief RS shift manager Perevozchenko.*

Kudryavtseva *- Did you instruct them to leave the Unit?*

Dyatlov *- No.*

Kudryavtseva *- And when did they leave it?*

Dyatlov *- At about 4 a.m.*

Dyatlov's defender *- Do the case file materials contain protocols of previous rundown tests?*

Dyatlov *-Yes.*

Dyatlov's defender *- With whom could Kryat discuss the allowed power level?*

Dyatlov *- With Borets.*

Fomin's defender *- What was your personal participation in development and coordination of the program?*

Dyatlov *- Metlenko approached me with the draft program. We discussed the draft. Then I instructed him to discuss the draft with TICS, RS and CCF. He did it all.*

Fomin's defender *- Dis you see the program's deficiencies at that time?*

Dyatlov *- No.*

Fomin's defender *- Did you discuss it with Fomin?*

Dyatlov *- No. I told Fomin on coordination of the program.*

Fomin's defender *- Did Fomin provide his consent on disabling SDS-5 on cut-off of 2 TGs?*

Dyatlov *- No, he did not.*

Fomin's defender *- You were considered as the most experienced specialist. Why did not you tell Fomin, that Lyutov should be involved?*

Dyatlov *- I told Fomin that it was not agreed.*

Fomin's defender *- Were you satisfied by your official position?*

Dyatlov *- Perfectly. I have never sought a career.*

Fomin *- Why did not you refuse to execute the program as it was not agreed?*

Dyatlov *- I told you about that, but you did not respond. Unfortunately, it was not the first such case.*

The presiding judge *- Fomin, do you want to ask Dyatlov something else?*

Fomin *- He had to execute the program without deviations.*

Kovalenko's defender *- The design-specified list of test programs was approved by the superior organisation. Was it necessary to agree the working program with the superior organisation and the Nuclear Safety Dept.?*

Dyatlov *- Yes.*

Kovalenko's defender *- Who installed the MCA button at the Unit Control Console? Was it necessary to issue a special authorisation to do that?*

Dyatlov *- The installation was made by ES. And Kovalenko signed the program.*

Rogozhkin *- Were you at the NPP on April 25?*

Dyatlov *- Yes.*

Rogozhkin *- Did you read the operational log of Unit 4 chief shift manager?*

Dyatlov *- No. I only listened to verbal reports.*

Laushkin's defender *- Were you aware of the nuclear safety prescriptions drafted by Laushkin?*

Dyatlov *- Yes. He provided them to me.*

The presiding judge *- Under what charges do you plead guilty? Please, specify your position. Specifically.*

Dyatlov *- 1) in two - three MCPs flow rates exceeded 7 thousand* m^3*/hour;*

2) a delay with activating the SDS-5 button;

3) a failure to instruct to raise the power up to 700 MW after the fall;

4) the reactivity margin less than 15 rods by the moment of insertion.

I can provide explanations on all these matters.

The presiding judge *- Does this mean that you admit only your partial guilt under Article 220 (Violation of safety rules at explosion-prone facilities or sections)?*

Dyatlov *- Yes.*

The presiding judge *-* ***<u>Defendant Kovalenko</u>****, what do you want to explain us?*

(Kovalenko comes to the witness' table)

<u>Kovalenko</u> *- After graduation from Tomsk Polytechnic Institute (Physical Engineering Department, a physicist-engineer) I worked at SCP (the Siberian Chemical Plant) up to 1975. For some time I worked as a full-time YCL Secretary. I started my work at the Chernobyl NPP as a CRCE, then (up to April 1980) as the Chief Engineer on operation in RS-1. Then, until 1983, I worked as the RS chief shift manager. Since 1983 I worked as the deputy chief RS manager on operation. Since October 1, 1985 I worked as the chief manager of RS-2.*

I have no information on previous rundown tests and their results. I know only the tests that were conducted in my presence...

I think, that I cannot be charged in signing the program. The program did not instruct to disable safety systems. As for the ERCS, ES and TICS personnel explained me that there was a high probability of launching ERCS on activation of the MCA button - these events could result in technological malfunctions. Therefore, I signed under disabling 3 sub-systems of ERCS…

I ask the court to request the Regulations of RS-2 approved in 1984. The Regulations specify what other NPP sections are responsible for at the RS equipment.

As for the charges: I did not ensure presence of Nuclear Safety Dept. at the tests, but it is their own responsibility!

I could not be present at the Unit that night, as in the morning of April 26 I was to be present in the course of the execution of the Unit air cooling program, to be conducted by NIKIET specialists requested. Earlier, the NPP CE warned me personally that I had to participate in the execution of the latter program. And in the night to April 26, the senior RS master was expected to attend.

As for the charges in violation of safety rules of explosion-prone equipment. However, the Technological Regulations, the Construction Standards and Norms, and NSR Certificate of the reactor unit do not categorise RS as an explosion-prone facility.

***The prosecutor** - Are you responsible for nuclear safety in the Reactor Section?*

***Kovalenko** - I am responsible according to the job description.*

***The presiding judge** - Could you specify the main cause of the explosion?*

***Kovalenko** - I cannot specify such a cause.*

***The presiding judge** - Maybe nobody can specify the cause. When did you look the rundown program through?*

***Kovalenko** - Metlenko familiarised me with the program in 1 - 2 hours before the initially specified time of its execution. I studied it very closely (for 15 minutes).*

***The prosecutor** - Did you know that vibration measurements were carried out simultaneously?*

***Kovalenko** - No.*

***The prosecutor** - Nobody told you about that?*

***Kovalenko** - No.*

***The prosecutor** - Did you know that in the morning of April 25, the reactivity margin reached 13.2 OCRs?*

***Kovalenko** - Yes. I got that information from the NPP chief shift manager report at the morning operational intercom briefing. Frolovskiy immediately interfered and the CE said that the issue would be decided upon separately. I understood that as agreeing the further operations. Later on, the reactivity margin reached more than 17 OCRs. Toptunov went home, after turning his shift out. I wanted to ask him to provide an explanatory note on reduction of the reactivity margin on the next day.*

***The prosecutor** - What should you do if informed on ORM decrease under 15 OCRs?*

***Kovalenko** - To shut the reactor down.*

***The prosecutor** - Do you feel yourself at least a little bit responsible for what had happened in your section? Your personnel, with your own hands did it!*

***Kovalenko** - I think that the court will define the degree of our responsibility.*

The prosecutor *- Was the Director present at the operational briefing when NPP chief shift manager reported the ORM lower than 15 OCRs?*

Kovalenko *- Intercom briefings are conducted by the Director, therefore he was present.*

An expert *- How do you, as a specialist, imagine the possibility of the reactor's runaway and explosion?*

Kovalenko *- None of our documents, none of our manuals suggest that our reactors can explode.*

The expert *- What is - as you think - a runaway?*

Kovalenko *- Runaway means fuel melting.*

The expert *- Who had notified you on the accident?*

Kovalenko *- A car was sent to take me, and I arrived at the NPP site at about 5 a.m. The Director expressed his disapproval that I arrived late. Later, it was identified that my phone set malfunctioned. The Director instructed me to go to the Unit and report the situation every 15 minutes.*

Kovalenko's defender *- Being informed that ORM is under 15 OCRs, could you order to shut down the Unit?*

Kovalenko *- I did not have such powers.*

Kovalenko's defender *- And who could do that?*

Kovalenko *- According to the Regulations, the operational personnel had to do that.*

Bryukhanov's defender *- What instructions did you get from Bryukhanov?*

Kovalenko *- I knew my duties, so the Director's instruction was enough. When I made my phone reports I mainly communicated with Gellerman and Komissarchuk, not with him.*

Bryukhanov's defender *- Did you know the radiation situation?*

Kovalenko *- While going to the Unit, I visited the radiation control panel and asked Krasnozhen on the matter. He said - 500 at the control panel (18 mSv/hour), and over 1000 µR/hour (36 mSv/hour) farther. I asked him, how much higher than 1000 µR/hour (36 mSv/hour)? He answered that it was surely higher in about 100 times.*

Bryukhanov's defender *- When did you leave the Unit?*

Kovalenko *- At about 10 a.m. My personnel had already left the Unit. I left the Unit as instructed by the NPP CE for health reasons.*

Bryukhanov *- I ask to clarify, what a response it was and whose to the NPP chief shift manager information on the reactivity margin less than 15 rods.*

Kovalenko *- Fomin said that the issue would be discussed later.*

Fomin's defender *- Why did not you participate in the program execution? Did the NPP CE instruct you to participate there personally?*

Kovalenko *-No. He instructed me to participate in the another program on the next day.*

Laushkin's defender *- You said that Frolovskiy took part in the intercom briefing. What did he ask?*

Kovalenko *- He asked to specify the reactivity margin but at that moment the connection failed.*

A people's assessor *- What kind of equipment is installed in your section - are the equipment items explosion-proof or standard?*

Kovalenko *- Standard.*

The people's assessor *- How do you think, are you guilty in the accident to a some extent?*

Kovalenko *- I think that I am not guilty in the accident.*

The presiding judge *- Therefore your signature under the program is a mere formality, is not it?*

Kovalenko *- No, but I explained its sense.*

The presiding judge *- Kovalenko asked the court to introduce the RS Regulations to the case file materials. What is your opinion?*

The court *- To satisfy the request.*

(the session ended at 19:12)

10. 07. 87

Session # 4 11:00

The presiding judge *- **Defendant Rogozhkin**, what would you like to explain us?*

Rogozhkin *- I would like to start from 25.04.86, when the request to shut down Unit 4 with a rundown was granted (we worked from 0 to 8:00). On April 25, Akimov had not have the program yet. Both Akimov and me were familiar with the previous stages of program and could discuss it. And we did it. The unit's power was reduced , but we had doubts that the reactivity margin would not decrease lower than 15 OCRs. By 8:00 it really happened, and it decreased to 13.2 rods. In the course of the intercom briefing I noted that at 8:00. Frolovskiy asked to repeat: "how many?", and Fomin said that we would discuss the issue separately.*

The presiding judge *- What were you obliged to do when ORM decreased to less than 15 OCRs?*

Rogozhkin *- According to the Regulations we had to shut the reactor down. But the Unit was already scheduled for shutdown, so we just reported the matter to the superiors. We decided to avoid extremes, as the Manual and the Regulations did not consider the parameter as a key one.*

On April 25, I arrived at the NPP in 50 minutes before the shift start time and was very surprised to find that Unit 4 was not shut down yet. I asked my back-to-back - chief shift manager Dik - what had prevented that? Dik answered that the grid operator prohibited to shut down the Unit at the day-time. Moreover, the Unit's power was not reduced , but by the end of the shift Dik decreased it to 760 MW (t).

After checking operations of units 1 to 3, I contacted Akimov. I asked him whether he sorted the program out. Then I got authorisation of the Kievenergo grid operator to launch the tests and called Akimov again. I asked him how preparations to the program were going on, whether all the necessary personnel were available, whether they were instructed. When I found that Dyatlov was the responsible manager in charge of the program, it was a heart-easing news. Dyatlov is a strict manager and Akimov is a very careful, professional chief unit shift manager. I was confident in them. I asked Akimov to notify me on any deviations from the program. And he did.

After 1 a.m. I saw on instruments, how they synchronised TG-8, how its power was raised. Then, they disconnected GT-8 and its load decreased to zero. At that time I heard a thud, like that of a heavy object falling. In 15 to 17 seconds, I had a systemic accident in my place (the second system of power lines and transformers went off, TG speed fluctuated, lighting did not go out but blinked). A little bit later the fluctuations ceased. I looked at the NPP total output meter, the NPP power remained the same as before - 2500 MW (electric). I announced via the intercom: "the operation mode stabilised, check the auxiliary equipment!". Then, I called the grid operator and asked what happened in their system. He answered - look at yours, you disconnected from 330 KV line.

At that time, a guard called and asked what happened. I told him: "Wait, we are too busy here".

Then, a guard watch commander called and said: "Unit 4 is on fire, the gates are open, firefighters arrived".

I asked Akimov on the intercom - what has happened? He did not answer but launched the accident notification. I run to Unit 4 Control Room and encountered 2 men in dirty coveralls nearby Unit 2. I saw dust and demolition debris nearby Unit 4 and went there by another route, through Unit 3 Control Room. The chief unit shift manager Bagdasarov reported that he had an accident, circulation pumps were lost. I provided necessary instructions and went to the Turbine Room. The situation there was grave. The main hazards were associated with oil and hydrogen. Dust was in the air, the roof collapsed and I was without a protective hardhat. I decided to return for it via Unit 3 CR. I asked Bagdasarov what he knew about the accident at Unit 4. He answered that he had lost communications. I ordered to make thyroid protection precautions for all. When I returned to CCR I reported to grid operator that we have an accident with a fire, with potential human casualties and - possible - rip-out of the reactor core. Then I again hurried to Unit 4 CR and met Toptunov, Akimov and Dyatlov there. I asked them what happened. Dyatlov made a helpless gesture and said: "Borya, we pushed SDS-5 button and 12 to 15 seconds later the unit exploded". I asked Toptunov: " Did you push SDS-5 button?". He said - "Yes, I pushed! But it seemed to me that the rods stopped and I killed power supply to the clutches to be sure".

I looked at the reactor control instruments: power - 0, rods inserted in the range from 0 to bottom terminators [7 m] according to selsins.

I looked at other instruments, the right separator - level 0, the right separator - apparently some level was visible there. I asked Akimov: "Do you supply water?" He said: "I supply it, but I do not know where it goes". The RSS chief was also present there, he said that the radiation level exceeded 1000 μR/sec (36 mSv/hour).

The RS chief shift manager Perevozchenko reported the situation: no fires, a some sort of glow in the central reactor room, light splashes like short circuits. Three people were missing.

I communicated with RSS chief Samoilenko at that time. As his DRG radiation meter went off-scale, I ordered to call in all his superiors, report the situation and find the necessary instruments. He said me that "GORBACH" system indicated "0" for Unit 4 and "off-scale" for Unit 3.

At that time, someone from CCF requested a radiation monitor to carry out a wounded man. They knew where he was located. A radiation monitor fortunately was present nearby and I ordered him there. Some time later they carried Shashenok out. But my shift personnel incorporated 200 more people. (All these events happened at about 1:40 - 1:50). I said Dyatlov and Akimov, that I return to CCR, and asked them to sort the situation out, to the extent possible. I helped to carry Shashenok to Unit 3 Control Room where we gathered Unit 4 personnel.

Then, I run to CCR and said to the phone operator: "Announce a general accident". She asked: "On which unit?" - "On the fourth". "Whom to call?" - "Call all". She disconnected.

Then I called "Soyuzatomenergo" and said: "The accident is extremely grave, radiation situation is unknown, gather all, all!" Then I called Kievenergo and did not tell them anything about the radiation situation. About 5 minutes later, Bryukhanov called. I told him everything briefly and proposed to connect him with Dyatlov. Bryukhanov said that he was already at the NPP site and would call Dyatlov himself. Then, the phones started to ring relentlessly and I communicated via two phones in parallel.

In addition, Samoilenko called me and asked whether I completed all items of the plan? I said: "Yes".

A little bit later, someone called me and said that graphite was found at the NPP site. At about 4 a.m. Major Telyatnikov came and asked for a radiation monitor to estimate radiation levels in the reserve accumulation area. I asked him about their situation. He said that no fires as such happened, just some small sources of fire were found. I noted a particular detail in his account: in contact with water some items started to burn more intensively. I realised that uranium released. I immediately went to radiation monitoring console. Krasnozhen and Kaplun were already present there. They were not able to explain the situation.

In addition, at about 3 a.m., Dyatlov called me and said that the situation necessitates shutdown of Unit 3. I said that I would agree the matter with the grid operator and Bryukhanov. Then, Unit 3 was shut down.

And now, as for the indictment - I worked with uranium-graphite reactors for 34 years, but nobody has ever mentioned that they explode. I found that in the Prosecutor Office.

As for the program - it was signed by all and approved by the NPP CE. I do not see any infringements in this connection.

As for the reactivity margin. Para 6.6.2 and para 6.6.4 of the Regulations are not relevant there, as we had a load reduction instead of a shutdown.

As for the Accident Mitigation Manual:

- *I notified the superiors on the accident (through the accident notification [system]), as well as "Soyuzatomenergo";*
- *excessive personnel and the wounded were evacuated from the strict control zone;*
- *I maintained operational contacts with the Civil Defence (CoS Bryukhanov).*

In other words, the plan was executed automatically.

There were five types of accidents: technological, fire, radiation, nuclear, general. In some cases we were expected to switch ventilation on, in some other - to switch it off. Therefore, when we found that it is dirty outdoors, we switched the plenum ventilation off.

We evacuated the personnel, we failed to find only one person - Khodemchuk.

We shut down Unit 3 according to emergency procedures when the risk of loss of circulation pumps emerged.

We organised thyroid protection precautions for the personnel.

We notified the personnel on the accident.

All affected persons were sent to the medical facility.

I asked Bryukhanov to replace Akimov.

***The prosecutor** - As I understand, Rogozhkin denies all the charges. In other words, should the situation emerge again, you would act in the same manner?*

***Rogozhkin** - I asked this question to your officials.*

***The prosecutor** - You should not ask. Would you act in the same manner?*

***Rogozhkin** - Yes.*

***The prosecutor** - What is meant by ensuring safety of works under the program?*

***Rogozhkin** - I controlled implementation of the program.*

***The prosecutor** - And that is all? You could not study the program in a day!*

***The assistant prosecutor** - When did you get information on April 25 that the ORM is lower than 15 OCRs?*

***Rogozhkin** - At about 7:40.*

***The assistant prosecutor** - What should you do according to the Manual?*

***Rogozhkin** - To shut the reactor down.*

***The assistant prosecutor** - But you did not do that.*

***Rogozhkin** - When Akimov reported to me on the ORM reduction, I asked him: "Did Fomin call you?" The matter is - at 6:30 Fomin called me and I* *reported the ORM reduction under 15 rods to him. In response he told me that he already called Akimov.*

The assistant prosecutor *- At what power level should the program have been implemented?*

Rogozhkin *- At 700 to 1000 MW.*

The assistant prosecutor *- In what aspects did the program fail to ensure nuclear safety?*

Rogozhkin *- It was already conducted earlier, thus it ensured nuclear safety.*

The assistant prosecutor *- Did you know about deviations from the program, on disabling safety systems?*

Rogozhkin *- No. Most likely in might be done according to Dyatlov's orders.*

The assistant prosecutor *- Could Akimov alone, without your authorisation, carry out the tests at the level of 200 MW?*

Rogozhkin *- He could do it if instructed by Dyatlov. He could not do it independently.*

The assistant prosecutor *- Yesterday, Dyatlov said that the NPP CE instructed Akimov to reduce power to 200 MW.*

Rogozhkin *- That is not correct. He said that he saw the power of 200 MW and decided that the NPP CE allowed to reduce power to 200 MW.*

The assistant prosecutor *- According to the Regulations, when should you disconnect TG-8 from the grid? Not according to the Regulations, but under a request to the grid?*

Rogozhkin *- Emergency regulating valves were closed at 01:23. TG-8 was disconnected from the grid at 01:03.*

The assistant prosecutor *- But according to entries in your operational log, it happened at 0:40.*

The assistant prosecutor *- Could the power fall at Unit 4 be observed in the CCR?*

Rogozhkin *- No.*

The assistant prosecutor *- Fomin, could Rogozhkin observe it?*

Fomin *- Only in an indirect manner, by checking TG-8 electric load. Rogozhkin himself might be unable to see that, as the time interval of 5 minutes is too short for that.*

The assistant prosecutor *- Rogozhkin, there is an entry in your operations log - "0:30 - report to Fomin". What was it?*

Rogozhkin *- Surely, Fomin himself called me.*

The assistant prosecutor *- Fomin, what could you say to that?*

Fomin *- I do not remember now. I could make a call. It is a routine case.*

An expect - *How do you understand reduced ORM? Why is it dangerous?*

Rogozhkin *- 15 rods are needed to compensate reactivity that might be introduced due to some faults.*

The expert *- But earlier you said that it is necessary to control the power density field, that it has some economic substantiation.*

***Rogozhkin** - Now I have a deeper insight into the problem. The best option is to operate without rods, that is the most economical option.*

***The expert** - How could you explain that at the beginning of the shift you had a power reduction of the reactor, not its shutdown?*

***Rogozhkin** - You may try to remove all rods in 15 minutes and to have 30 MW.*

***The expert** - Who had made the entry that by the beginning of the shift, on April 26, the power reached 760 MW?*

***Rogozhkin** - Dik.*

***The expert** - But your records specify that in the morning of April 25, ORM reached 13.2 OCRs?*

***Rogozhkin** - Yes, there is a record.*

***The expert** - How much time did the vibration measurement take?*

***Rogozhkin** - About 36 minutes. At different power levels - 300 MW, 200 MW.*

***The expert** - You said that metal uranium ignites in contact with water. Could you provide more details?*

***Rogozhkin** - I saw it when metal uranium contacted water.*

***The expert** - But does RBMK contain metal uranium?*

***Rogozhkin** - No, it contains uranium dioxide. But I had such associations.*

***The expert** - You categorised the rundown test as a statutory one. Are not you concerned by the fact that the unit mechanisms were connected to different power supply sources?*

***Rogozhkin** - No.*

***The expert** - I have an impression, that the Chernobyl NPP systematically deviated from the due documents for economic reasons.*

***Rogozhkin** - You should not implicate economics here.*

***The presiding judge** - Your testimony suggests that. The expert asks correctly.*

***The expert** - Toptunov did not qualify fully for a chief reactor control engineer. Why had you allowed to impose such a heavy load onto him?*

***Rogozhkin** - On April 25 I asked Akimov about Toptunov's performance in a transitional mode. He answered that he seemed to perform normally.*

***The expert** - Do you comply with "Soyuzatomenergo" guidelines to terminate all works 1 hour before the shift change and 1 hour after it?*

***Rogozhkin** - Yes, we apply the rule to avoid conducting anything a half hour before the shift change and a half hour after it.*

***The expert** - You said that the chief shift manager of the Occupational Safety Dept. had only a DRG meter available. But do you know that in your shift five DP-5 meters were available at workplaces?*

***Rogozhkin** - I saw that Kaplun himself run with a DRG, so they did not have DP meters.*

***The expert** - You very easily sacrificed people, you said that the situation necessitated that.*

Rogozhkin *- This is not correct. I did not send people anywhere.*

The experts *- So, you are not a manager. Why did you admit the new shift personnel to the NPP?*

Rogozhkin *- I did not admit people to the NPP.*

Rogozhkin's defender *- What was the ORM on April 26, at the beginning of the shift?*

Rogozhkin *- 24 rods, at the reactor's power of 1600 MW.*

Rogozhkin's defender *- Were there cases at the Chernobyl NPP, when reactors were shut down due to ORM decreases?*

Rogozhkin's defender *- No.*

Rogozhkin's defender *- When did you leave the NPP?*

Rogozhkin *- As authorised by Fomin, after 8 a.m.*

Bryukhanov's defender *- Was there a conversation between Fomin and Frolovskiy on April 25, on the matters of ORM decrease under 15 OCRs?*

Rogozhkin *- I do not know. I turned my shift over and went home.*

Bryukhanov's defender *- Fomin, did the conversation happen?*

Fomin *- No, I got information about that only yesterday. Frolovskiy did not approach me.*

Fomin *- Rogozhkin, where there cases when the NPP CE forced you to violate the Regulations?*

Rogozhkin *- No, he never forced, but there were authorisations to work with deviations.*

Dyatlov *- Did I relieve you from management of the accident mitigation works?*

Rogozhkin *- No.*

Dyatlov *- In the course of the pre-trial investigation you testified that the Dyatlov admitted the firefighters in. Who should admit?*

Rogozhkin *- I will look into the Guidelines now …*

A people's assessor *- Do you reject all the charges?*

Rogozhkin *- I am not guilty.*

The people's assessor *- The accident has happened. Should the causers be found?*

Rogozhkin *- Yes, they should. But it is a difficult thing to do.*

(break from 13:50 to 15:00)

The presiding judge *- Defendant* ***Laushkin,*** *what would you like to say in connection with the charges against you?*

Laushkin *- I was indicted on December 4, 1986. I provide the following testimony on the subject matter of the indictment.*

In the course of my work I followed GAEN Regulations, NSR and other guidelines and regulations…

In the course of my work I sometimes disclosed deviations from regulations and manuals that were not known to the supervisory bodies, as the NPP *personnel failed to notify them. I promptly informed my superiors by phone on the violations identified and reflected these violations in my quarterly reports.*

In March 1983, the Chief Inspector Kozlov ordered me to check the nuclear safety level of the Chernobyl NPP. A Commission, chaired by Smirnov (I participated in the Commission) examined operations of the Chernobyl NPP from 1979 to 1983. The Commission's protocol was approved by Kozlov and sent to the Chernobyl NPP Director in the letter of March 28, 1983. The Protocol noted systematic deviations from the Regulations. After the letter, no systemic violations were observed but some attempts were made. In particular, in 1983, an attempt was made to raise a reactor power without waiting for the poison override time. When I got information about that, I called Kozlov in Moscow. He called Bryukhanov and demanded to stop the power increase. There was another case of poison override on power. The deputy CE Lyutov submitted his explanatory note to central GAEN bodies on the case. In the case of all violations I issued written prescriptions to Bryukhanov, Fomin, Lyutov. They either remediated them, or agreed some deviations with the Chief Designer, the Scientific Supervisor, etc.

One more example. "Soyuzatomenergo" CE Prushinskiy once sent a teletype, requesting reduction of the operational time at power level of 700 MW (e) from 36 to 24 hours. I demanded to agree the request with the Chief Designer and the Scientific Supervisor.

In 1985, a GAEN Inspection Team was established at the Chernobyl NPP. The team consisted of 6 persons - Elagina, Manko, Popov, Shevchenko, Laushkin and Frolovskiy. The Inspection Team was headed by Frolovskiy. I myself drafted the Inspector Job Description as a model one was not available. The Job Description was approved by the acting Chief Inspector of the South-west District Zavalnyuk.

My key task was associated with prevention of deviations from the NSR that might cause uncontrolled rundowns.

As for the program - the program of tests on Unit 4 Control Room was delivered to Unit 4 CR on 25.04.86. According to the experts, the equipment under the tests was not under control of the NS Inspector.

No accidents happened in the period of my work.

***The presiding judge** - Why are you silent about numerous cases of equipment failures and reactor shutdowns caused by the personnel?*

***Laushkin** - The charges of my indictment are outside my sphere of competence.*

***The prosecutor** - When was the Inspection Team established?*

***Laushkin** - In September 1985.*

***The prosecutor** - In the course of the pre-trial investigation you said that you did not behave in a persistent manner in relations with the NPP top managers on nuclear safety matters.*

***Laushkin** - Yes.*

***The prosecutor** - Do you agree with what you said in the course of the pre-trial investigation?*

***Laushkin** - No. I do not agree.*

***The prosecutor** - Do reactor safety issues belong to your sphere of competence?*

***Laushkin** - Yes.*

***The prosecutor** - I have a question. Bryukhanov, tell us please, did Laushkin work so good as he says?*

***Bryukhanov** - Yes. I was issued prescriptions by Frolovskiy and Elagina.*

***The prosecutor** - Did Laushkin demand you to comply with the prescriptions?*

***Bryukhanov** - He did not demand me to do it.*

***The prosecutor** - Is it possible to say that Laushkin worked to his full capacity? Would the accident happen if he had worked better?*

***Bryukhanov** - The accident would surely never happen if we all had worked better.*

***The prosecutor** - Tell us, Laushkin, were there cases when the Director or the CE assumed responsibility for violations?*

***Laushkin** - Yes, I already said about that.*

***An expert** - Did you know that the rundown program would be implemented?*

***Laushkin** - I did not know that.*

***The expert** - You said, that the tests were conducted with the equipment outside your sphere of competence?*

***Laushkin** - Yes.*

***The expert** - But does a turbine test affect parameters of the heat-transfer medium?*

***Laushkin** - Yes.*

***The expert** - So, you were expected to check it?*

***Laushkin** - No.*

***The expert** - Did you realise risks of ORM decrease under 15 OCRs before the accident?*

***Laushkin** - Yes.*

***Fomin's defender** -How did Fomin respond to your prescriptions?*

***Laushkin** - He append instructions for NPP sections, the sections identified actions and I controlled them.*

(break from 16:55 to 17:10)

***Sitnikova** Elvira Petrovna, year of birth 1941.*

For us, the NPP was not just a place of work, we were proud to work there.

When it happened, a phone rung at night. My husband said that a major accident happened and went to the plant. I was calm as I thought that is was a routine post-accident sort-out.

At 10:30 I called him and asked: "Will you return soon?" He said that he would not. I asked: "How do you feel", he said: "Bad". I told him to go to medical *facility immediately, but he said that he could not do it. Then I myself called the medical facility.*

Later on, when Tolya was in Clinic # 6, he told me that their sacrifices were not futile. They surely saved Ukraine and maybe a half of Europe as well. He did not blame anyone. I also do not blame anyone.

***Kudryavtseva** Tamara Alekseevna, year of birth 1957.*

We started to work at the Chernobyl NPP with my husband in 1981, immediately after graduating from the institute. My husband was proud to work at the NPP, he sought to enhance his professional skills and learned permanently. He worked as a senior mechanic engineer for 4 years. Then he started to learn to qualify for a CRCE. I thought that he had a dangerous work.

By the moment of the accident he had already passed all exams and was expected to start working as a back-up CRCE. On 25.04 he had a day off, but from 11 to 18 he was at work. Then, throughout the whole evening he was thoughtful and played with children. As I felt, he went to work in a dismal mood. In the morning he did not return home. A friend of him came to us and said to close windows and stay indoors. My husband's phone number was dead. I occasionally contacted his friend Vladimir Minin. He said that the whole shift personnel was moved for medical examination. In the evening I run to the medical facility. I managed to see him through the window. He was swollen, his skin was red, he squinted. They delivered him to the medical facility at about 5 a.m. He vomited all the night and felt dizzy.

I heard testimony of the defendants and I feel indignant on them. They say that they did not see and did not know, but other people worked at that time ...

All the men who died behaved honourable.

He was awarded the Order of Honour, but my sorrow is too great.

And one more note - in the day of evacuation we waited for a bus near the entrance for about 1.5 hours, holding our children in arms.

(break from 17:45 to 17:55)

***Metlenko** Gennadiy Petrovich, year of birth 1940. The chief test team engineer of "Dontekhenergo".*

In 1979, we started to review materials and prepare auto-launch modes [systems of emergency power supply of running down TG] in NPPs. Then we turned our attention to the rundown mode. In the case of 1st NPP stage we could not do it as the TG manufacturers did not equipped them by rundown units. The safety system concept of 2nd NPP stage stipulated powering feedwater pumps by a rundown TG.

In 1984, the tests at TG-5 failed, as the control signal of the rundown unit did not reach the TG.

In 1985, we could not visit the NPP (we worked at the Armenian NPP at that time) and the Chernobyl NPP conducted the tests independently. They failed.

In March 1986 we started to draft the program, to this end I came to the Chernobyl NPP with a team. Starting from April 14, I agreed the program (with deputies of the chief ES manager - Kuznetsov and Metelev, CCF - Aleksandrov, the chief of TICS - Borodavko). I did not agree the program with Fomin personally. I submitted it to him for approval via his secretary.

On April 24, we arrived at the NPP site long before the test. It was associated with the fact that we can connect out instruments only when the Unit is granted a shutdown request for repairs. We started to connect the instruments at 0:00 of April 25. Then, the test was postponed to 21:00.

Dyatlov managed the tests. First, the vibration tests were completed.

***The presiding judge** - Did it disturb your work?*

***Metlenko** - Yes, to some extent, as we had to switch off some our instruments and the NPP equipment items (instruments, pumps, etc.) and then to switch then on again.*

***The presiding judge** - How do you assess the working conditions, as normal or otherwise?*

***Metlenko** - They were rather difficult. At some time, there were even plans to re-allocate our runaway testing time to CCF (or KhTP). On April 26, at about 1 a.m. they finally decided to submit the program to me. At 1:10 - 1:15 Dyatlov started to hurry all. At 1:23 the program was launched. On my order: "Attention, oscillograph, launch" - we started. I controlled the TG rotation rate (at about 2500 rotations of TG- 8 Akimov ordered the CRCE to shut the reactor down). A few seconds later, the explosion struck. To my view, it was a powerful prolonged hydraulic impact. The lighting blinked. Dyatlov ordered to move to the RCR. But logic panels were operational, noise subsided and Dyatlov ordered all to remain the in place. Then, by Akimov's orders, diesels were launched, emergency feedwater pumps, manual valves at the feedwater units were opened. Then, my instruments went dead. Akimov ordered to assist the operator in opening the valve and I went to help him. Then I returned to the Unit CR and Dyatlov ordered me to remove my personnel. They were scattered in different rooms and I started to run round the place to find them. I gathered all of them and led them out.*

And now, as for the program - I drafted the backbone of it.

***The presiding judge** - There are no claims against you, you are not a specialist in the sphere.*

***The prosecutor** - Was it necessary to disable SDS-5 on disconnection of 2 TGs?*

***Metlenko** - No, by no means. We said that the reactor should be shut down according to our program.*

***The prosecutor** - Who proposed the idea of disabling ERCS?*

***Metlenko** - As I remember, Aleksandrov (the chief manager of CCF) urged me and Dyatlov on the matter.*

***The prosecutor** - Please, tell us about the sequential order of activation of the MCA button.*

Metlenko *- His command on the MCA was delayed by 1 - 2 sec after closure of the emergency regulating valves.*

The prosecutor *- Earlier you said about 4 - 6 sec.*

Metlenko *- I agree. It was estimated by the oscillograph records, it is more precise.*

The assistant prosecutor *- Why was interested in the program implementation?*

Metlenko *- The Chernobyl NPP only.*

The assistant prosecutor *- But was the rundown necessary?*

Metlenko *- I can state clearly that it was absolutely necessary.*

The assistant prosecutor *- Do you agree that the power of 200 MW was needed?*

Metlenko *- It was sufficient to meet the own needs. We needed 30 - 50 MW (electric), but technologists demanded 600 - 700 MW for the reactor.*

The assistant prosecutor *- In the course of the pre-trial investigation you said that you yourself requested the power level of 200 MW and that the technologists said that it could be done only in the last moment, while before that they should operate at the level of 700 - 1000 MW.*

Metlenko is silent.

The assistant prosecutor *- Were all the Dyatlov's orders complied with obediently?*

Metlenko *- Yes, I think it was so.*

The assistant prosecutor *- Did you know about the power reduction?*

Metlenko *- Yes, there was something at about 00:28. Dyatlov came away from the console, mopping his brow.*

The assistant prosecutor *- So, you confirm presence of Dyatlov at that time near the CRCE console?*

Metlenko *- Yes, as I remember he was there.*

An expert *- When did you leave the NPP?*

Metlenko *- I went away after 12.*

The expert *- How many people were at the NPP site?*

Metlenko *- About 120 - 150 people. Some waited for transport, some other made blood tests.*

The expert *- Did you hear the accident alert notification?*

Metlenko *- No, I did not hear anything.*

Dyatlov's defender *- Where was Dyatlov staying predominantly?*

Metlenko *- He mainly stayed in the Unit Control Room.*

Dyatlov's defender *- In some particular place of the Control Room?*

Metlenko *- No, he walked to and fro in the whole Control Room.*

The prosecutor *- Did you see him going away or coming back?*

Metlenko *- I do not remember, maybe.*

Dyatlov's defender *- Besides the situation when he came away and said "Ooh!", were there other tense moments?*

***Metlenko** - Yes, there were some. For example, in the course of the vibration test.*

***Dyatlov** - Please specify where Akimov stood after closure of the emergency regulating valves?*

***Metlenko** - To the left from CTCE.*

***Dyatlov** - With what sort of voice had chief unit shift manager ordered to shut the reactor down?*

***Metlekno** - His voice was calm.*

***Dyatlov** - Did you hear a vibration or noise before that?*

***Metlenko** - No, everything was calm.*

***Dyatlov** - Did you have a conversation with Kukhar after the accident, on April 26?*

***Metlenko** - Yes, for the whole morning of April 26.*

***Dyatlov** - Was there a conversation on April 26 (before the accident), when you said that you would demand cancellation of the contract if the works could not be completed that day?*

***Metlenko** - Yes, there was one, after disputes with KhTP representative Kabanov.*

***Kovalenko's defender** - Who defined the range of responsible representatives of NPP sections for the rundown?*

***Metlenko** - I cannot answer the question.*

***Rogozhkin's defender** - Did Akimov asked the NPP chief shift manager for something in your presence?*

***Metlenko** - I do not remember.*

***Laushkin's defender** - How do you think, did the program interfere with nuclear safety issues?*

***Metlenko** - The issue is obscure for me. It interfered with the Unit, therefore it interfered with the reactor.*

***A people's assessor** - You visited many NPPs. How do you assess the level of management at the Chernobyl NPP in comparison with other NPPs?*

***Metlenko** - In comparison to others, the situation there was more orderly and organised.*

WITNESSES TESTIFY

11. 06. 87
Session # 5.

***<u>Tregub Yu</u>** <u>(the chief shift manager of Unit 4)</u> [1]: - By 00:00 of April 26, people started to gather in the Unit 4 Control Room. Representatives of the Chernobyl Commissioning Facility of "Smolenskenergonaladka" came: Palamarchuk and Shahsenok arrived there, as well as Kabanov from the Kharkov Turbine Plant and Metlenko from "Dontekhenergo". I saw Kudryavtsev,* *Proskuryakov, Kirshenbaum, Toptunov and Stolyarchuk. Orlenko was called in, as well as a deputy ES chief manager.*

To observe the events, I decided to stay at the console of the chief turbine control engineer (CTCE) nearby the control panel of turbine generator # 8.

At about 0:05 - 0:15 I heard a conversation between Akimov and Dyatlov. The conversation dealt with Dyatlov's request to operate the reactor at power level of 200 MW. Akimov had a program in his hands and argued, apparently he objected. I decided so by his face expression, his body language. As a result, I thought that the power reduction was made according to Dyatlov's instructions. However, I had not heard him directly ordering that. Then, the alarm signal of a water flow rate decrease was heard. The signal alerted me and I appeared near the CRCE. I also heard Akimov's order: "Maintain power, maintain power!"

While switching from automatic controls to manual ones Toptunov made the power fall, I also heard that. But he made correct steps to raise it. Akimov assisted him. The CRCE mainly focused on the rods. The control console is large and very inconvenient for use. One should be particularly careful to release control rods in such a situation. Adsorbers should be removed to approximately equal heights each. I consulted Toptunov on selection of particular appropriate rods. He did as he knew.

I also noticed Dyatlov who was standing behind me. When we again reached the power level of 200 MW, I returned to the CTCE console. When I looked at the distribution panel for the last time before the accident, I saw that the CRCE removed about a half of the rods close to upper terminator switches, while the rest were removed for about 2 metres. The last ORM value I saw suggested that about 19 rods were located within the active core.

I witnessed the disabling of automatic SDS-5 signals. I saw how the MCA button was quickly installed. I saw Metlenko with a phone set.

***The presiding judge** - Who had disabled SDS-5 automatic system?*

***Tregub** - Such an order should be issued via the chief shift manager of the Unit. The authorisation should be made by the NPP chief shift manager. I do not know how it was made in that particular case.*

***Dyatlov** - But if a safety system is disabled according to the Regulations? Should a Unit shift manager ask for an authorisation?*

***Tregub** - In the case of some safety systems, authorisation is not needed.*

***The prosecutor** - Your words suggest that Dyatlov ordered Akimov to reduce the unit power to 200 MW.*

Tregub is silent.

***The prosecutor** - Please, read out the confrontation protocol. (The protocol was read out).*

***Tregub's answer** to a similar question:*

"I completed my shift at 00:00 and at 00: 15 I stood nearby Akimov's table. Dyatlov ordered to reduce power to 200 MW, Akimov objected".

***The presiding judge** - Is that correct?*

***Tregub** - Yes. I checked up, the time was not later than 00:15.*

The presiding judge *- Where was Dyatlov in the course of the power fall?*

Tregub *- When the power fall happened, I saw Dyatlov near me.*

The presiding judge *- Who had ordered to shout the reactor down?*

Tregub *- I heard Akimov's order: "CRCE - shutdown the reactor!", and the response "The reactor has been shut down!". But it happened after the experiment.*

(break from 14:00 to 15:00)

<u>Court's questions to M. Lyutov</u> *[2]:*

An expert *- Were physical calculations made to substantiate the launch of the test in the most favourable moment in terms of reactivity? Were calculations made to estimate the course of reactivity change for reduction of the reactor power from 1600 to 200 MW?*

Lyutov *- It seems that the schedule was not a very thought-out one.*

The expert *- Why 200 MW is worse than 700 MW?*

Lyutov *- At such a power level, the void effect is more marked.*

The expert *- Did you know that the TG rundown experiment would be conducted?*

Lyutov *- No, I did not know. I knew on the shutdown only. I was told on the experiment by Kovalenko, after the accident.*

The expert *- Were you ordered to ensure non-disclosure of information on results of express analysis of spectrometry measurements made by your specialists?*

Lyutov *- No, I was not ordered.*

Bryukhanov's defender *- What were your duties under the Civil Defence action plan?*

Lyutov *- The chief of the reserve (field) staff.*

Bryukhanov *- Who approved the first criticality program?*

Lyutov *- The Chairman of the State Commission.*

Bryukhanov *- Who examines the on-duty personnel prior to the first criticality launch?*

Lyutov *- A commission chaired by NIKIET.*

Bryukhanov *- What are your additional duties in the Civil Defence staff (with the Occupational Safety Dept.)?*

Lyutov *- Only duties of the chief of the reserve staff.*

Bryukhanov *- Did I instruct you to check why air emissions were observed to increase in the course of shutdowns of units 3 and 4 at operating exhaust radioactivity suppressor?*

Lyutov *- This is something different, I do not remember.*

Fomin's defender *- Why did not a representative of the Occupational Safety Dept. participate in the experiment?*

Lyutov *- The program was not agreed with me, it was not agreed with the Occupational Safety Dept.*

Fomin *- Who in the Chernobyl NPP Administration is responsible for nuclear safety?*

Lyutov *- I am responsible.*

Fomin *- Were you notified on April 26, 1986 (against your signature) about the shutdown schedule, that listed the experiments?*

Lyutov *- I do not remember, maybe it was so, but the Electric Section was listed there as the responsible party.*

Fomin *- When you were the acting NPP CE, you approved the program of 1985, even without agreeing it with the Occupational Safety Dept.*

Lyutov *- Yes, I had powers to do it, as I fulfilled duties of the deputy NPP CE on science. While you had to agree it. Moreover, at that time the program was implemented after scheduled maintenance repairs, with a high ORM.*

Fomin *- The Unit was being shutdown for more that a day. Why did not any representative of the Nuclear Safety Dept. participate?*

Lyutov *- Chernyshev was present initially, then he went out. They should have called him in for the night.*

Fomin *- Why a special request? There are procedures. A worker has rest and calls the NPP himself to ascertain when he should arrive.*

Dyatlov *- There is an order of the NPP Director providing for mandatory presence of the Chief/deputy Chief of the Nuclear Safety Dept. in the course of reactor launch of shutdown works.*

Lyutov *- I did not know.*

(Then, the court checked whether the order existed. They found it to exist).

Fomin *- I want to explain to the court that on April 26, the Occupational Safety Dept. lost the initiative to ensure nuclear safety.*

Dyatlov *- Were you a member of the first criticality launch commission?*

Lyutov *- Yes.*

Dyatlov *- What were the reasons of the commission on the first criticality launch to commission the Unit, when some rods have positive reactivity when inserted to the active core, while some other control and safety rods had zero reactivity (15 to 17 rods)?*

Lyutov *- The effects were estimated but they were small.*

Dyatlov *- Who, had allowed then to apply results of these experiments to the hot active core of a steady state reactor?*

Lyutov *- The events that had happened, were possible only provided the deviations in the course of the tests:*

- a low reactivity margin;

- low feedwater flow rate;

- high flow rate of water in MFCC.

Dyatlov *- Did you explain to the personnel, how dangerous these things are?*

Lyutov is silent.

Rogozhkin's defender *- Did you know on April 25, 1986 that the reactivity margin was lower than 15 rods?*

Lyutov *- I know that now, but I did not know at that time.*

Laushkin's defender *- Did you receive prescriptions issued by Laushkin?*

Lyutov *- Yes.*

Laushkin's defender *- Did they include substantial ones?*

Lyutov *- Yes.*

Laushkin's defender *- Did he followed them up?*

Lyutov *- Yes.*

An expert *- By an order of the NPP Director (the Civil Defence CoS), you were appointed the chief of the computational and analytical team. What did you do, specifically?*

Lyutov *- I gathered the people, assigned tasks. We estimated subcriticality of Unit 4 reactor, etc.*

G. Lysyuk *(a senior master, ES) - I was a senior master of the Electric Section before the accident. I looked the program through (the draft program) a week before. I had a task of back-up one of outputs of the MCA unit. We connected to the operational circuit in late hours of April 24, 1986.*

As for April 26 - when preparatory works were under way, I stood in the darkest corner to avoid disturbing people. Then, instructions were provided. As I understood Metlenko, we were expected to wait for his order "oscillographs - launch" and then for "MCA button - push". But he ordered only once and then he looked at me and remained silent. So, I pushed it. The delay was 1 to 3 seconds long, but I will not dispute oscillograph's data.

Then there was a calm conversation that the reactor should be shut down. Then, the CRCE shouted that the reactor's power raises with abnormal rate. Then Akimov sharply ordered "SDS-5!". He removed a cover paper from some button and someone pushed it - either he himself, or Toptunov. Then the explosion hammered. When the explosion boom started to die down (in about 1 - 3 sec), I saw Dyatlov who moved closer from the right (emergency) side to the centre of the Unit CR. He said that all should relocate to the reserve Control Room. But nobody moved there. Akimov shouted "Diesels!" and started to switch cooling pumps on.

Reports came on fires in the turbine room building, at the feedwater pumps platform and so on. Akimov tried to call firefighters, but communications failed.

And one more thing - a radiation monitor did not allow people to leave A&UB-2, there were about 40 to 50 of us there. When asked about the situation he answered - up to 40 thousand β - particles/cm^2 per minute.

The presiding judge *- But what a sort of atmosphere it was at the Unit before the launch of the test?*

Lysyuk *- There was some nervousness in connection with the vibration-checking personnel.*

The presiding judge *- That order of Akimov - "push SDS-5 button" - was it before the explosion or after it?*

Lysyuk *- Before the explosion.*

The prosecutor *- The CRCE shouted that the reactor's power changes with abnormal rate - was it before the SDS button had been pushed?*

Lysyuk *- Yes.*

Dyatlov *- Where was Akimov staying after closure of the emergency regulating valves, but before "SDS-5"?*

Lysyuk *- Akimov was out of view, I stood with my back turned to him.*

Rogozhkin *- When did you leave the Unit CR?*

Lysyuk *- 5 to 10 minutes after that.*

Rogozhkin *- Did you hear the automatic accident notification message?*

Lysyuk *- I heard somewhere, maybe in the passage - "Accident at Unit 4".*

The presiding judge *- Who was in command of the whole tests?*

Lysyuk *- Metlenko was the technical chief manager and he contacted Dyatlov all the time (verbatim - N.K).*

The presiding judge *- Was Dyatlov staying in the Unit CR all the time?*

Lysyuk *- He was out for some time, but I cannot recall how many times and for how long.*

The presiding judge *- What do you know about the radiation level?*

Lysyuk *- I know that it was high. Radiation monitors said that the situation was bad.*

S. Gazin *(CTCE of Unit 4). - On April 25, I worked from 16 to 24. After the shift I stayed to see the experiment. We stayed as observers.*

On 26.04.86, at about 1 a.m. I noted that something was wrong with the apparatus. It was clear that the reactor loses power. Initially, CRCE Toptunov started to raise the power alone. He very quickly pushed some buttons. Then people gathered around the CRCE console.

I saw decreasing pressure in the separators, closure of emergency regulating valves, saw that the TG started to run, and a minimal electric power emerged. Then each of 4th MCPs was switched on at every side.

Shortly after that, the rundown test was started. The MCA button simulated an emergency.

The personnel were instructed. Metlenko explained what commands he would give. As I understood him, on him command - "launch" - the MCA button should be pushed and the apparatus should be shut down. After the accident I get information that the reactor was not shut down by the MCA button, it was shut down by SDS-5 button after closure of the emergency and regulating valves.

I was interested in reduction of the TG rotation rate after closure of the emergency and regulating valves. The first stroke happened at the turbine rotation rate of 2400 rotations/min. The stroke was strong. I looked at the CRCE console. Toptunov was saying something to Akimov. Later, I heard that Akimov said "clutches' power supply".

Then Unit 3 reported loss of water level in the pressure pond.

As for the radiation situation - Samoilenko run in to the Unit CR, he said that the exposure dose rate exceeded 1000 μR/sec (36 mSv/hour).

The presiding judge *- Did you witness the power reduction at the beginning of the shift?*

Gazin *- I was there.*

The presiding judge *- What could you tell the court about the event?*

Gazin *- In the course of the power fall, Akimov, Dyatlov and Tregub came to Toptunov and did something there. The power decreased almost to zero. Then, they raised it to 200 MW.*

The prosecutor *- Earlier you said that main safety valves opened before the accident?*

Gazin *- I did not see it myself, Stolyarchuk told me about that.*

An expert *- You stood near Kirshenbaum. What did he do?*

Gazin *- He maintained pressure in MFCC.*

Expert Martynovchenko *- Who was in command on the experiment?*

Gazin *- Metlenko defined the key aspects of the program. But Dyatlov was also involved.*

The expert *- When did you leave the unit?*

Gazin *- For an hour, or an hour and a half we stayed in the open, nearby Unit 4, than we went to A&UB-1. We stayed there for about 40 minutes, then we went to the bunker and from the bunker we went home.*

Fomin *- At reactor's power of 700 to 1000 MW, could you run TG-8 at 50 MW (electric)?*

Gazin *- Without problems. I could take extra steam from the condenser reducer.*

Dyatlov's defender *- What Dyatlov's orders do you remember, whom were they addressed to?*

Gazin *- I remember only the order to switch 4th MCP on.*

Rogozhkin's defender *- Do you remember whether the accident alert notification was launched?*

Gazin *- Yes, after switching all feedwater pumps on (notwithstanding that their manual valves were closed).*

V. Babichev *(the chief shift manager of Unit 4). - In the morning of April 26, I was awakened by a phone call. It was 4:45. They said that a "General Accident" happened. I made a call to NPP chief shift manager Rogozhkin B.V., and he said that a bus would be available at 5:15 at the bus stop in the city.*

When we approached the Chernobyl NPP, the shape of Unit 4 construction appeared blurred to me, and some straw-colour light was seen emanating from beneath.

I found Dyatlov in the bunker. He ordered me to replace the chief unit shift manager A. Akimov and switch on a pair of emergency feedwater pumps. Before I reached the Unit I met the chief of the Occupational Safety Dept. and tried to ascertain the radiation situation. He did not tell me anything grave.

In the Unit 4 CR, Fomin, Sitnikov, Chugunov, Orlov, Akimov, Toptunov, CUCE, CTCE were present. Akimov told Fomin on what happened, and then all started to discuss the best option for supplying water into the active core to cool the *reactor down. Fomin thought that supply of water is the most important thing to be done. So we did.*

At 6 a.m. I said Akimov "You are free. Let us process the operation log". But we failed to find the log.

Later on, Lyutov visited Unit 4 CR, he reaffirmed that it is necessary to supply water to the active core. Fomin provided the same instructions. We twice went out to reserve CR with Lyutov, looked at the Unit.

At 7:30 Smagin arrived, we discussed questionable benefits of supplying water to the reactor, but we had no other orders. So, we decided to continue.

We went out to survey RS facilities with the Chief of RS-2 A. Kovalenko. We feared even assuming that the reactor was destroyed, but it really happened.

At 11:30, L. Vodolazhko called us and told him to relieve me for organising [emergency] personnel.

I did not familiarise myself with the program.

***The prosecutor** - How do you think now - was it a correct decision to supply water to the reactor?*

***Babichev** - I do not know. I can similarly ask whether it was a correct decision to throw lead into the reactor.*

***The prosecutor** - Did Rogozhkin coordinate actions of the shift personnel?*

***Babichev** - I worked without contacting him.*

***Yuvchenko A.** (a senior mechanic engineer, RS-2) - I was in the SMEs room, when explosions were heard. Walls are a metre-thick there but they appeared to me to cave inwards. The doors were knocked out by the impact wave. The phone communications failed. A little bit later a request was made from Unit 3 - they asked to deliver a stretcher for a wounded man there. I run out to the corridor and met operator Degtyarenko there - I hardly recognised him, he was burned by hot steam. He told me that operator Khodemchuk remained near the MCPs.*

We dashed to search for him. The left side of MFCC was almost intact, while the right side of MFCC literally ceases to exist. I saw Rusanovskiy there, he was in a state of shock, pointed to the gap and said "Valera Khodemchuk is there! MCPs have collapsed somewhere!".

I encountered a radiation monitor in a gas mask. He grumbled that everything was off-scale.

***The presiding judge** - How was Degtyarenko burned?*

***Yuvchenko** - We were hospitalised in the same clinic for almost a year. We were to be informed on switching the MCPs. Akimov issued orders. Khodemchuk and Degtyarenko stayed near MCPs. A strong hydraulic impact perforated some pipe and steam burned Degtyarenko's face. I did not know about activation of additional main circulation pumps. Akimov gave an order to the operators but they did not report to their managers.*

The below entries are quoted by "Chernobyl. How it Happened. The Inside View".

(A.Ya. Voznyak, S.N. Troitskiy. Moscow, LIBRIS, 1993)

A. Orlenko *(the chief shift manager, ES): - In the course of the experiment I had to observe changes in the rotor electric field. I controlled it by the ammeter. I noted that the current frequency decreased and then fallen. About 30 seconds after that vibration started.*

Turbine personnel needed some extra time as they had not managed to complete their measurements yet. The deputy chief of the Chernobyl NPP Turbine Section Davletbayev talked to Akimov or to Dyatlov that it was necessary to complete the vibration tests. There were some concerns that the reactor could be shut down and the tests would not be completed.

Davletbayev R*. (the deputy chief of the Turbine Section-2): - Dyatlov stayed in the Unit CR when the reactor power fell. I, as a representative of the Turbine Section, remained there to assist representatives of the Kharkov Turbine Plant. They wanted to measure vibration in the course of the rundown tests. Dyatlov allowed. I know that a power fall happened, that the reactor power was raised to complete the tests… In addition I have to admit some nervousness in the CR before the tests. Dyatlov said to Akimov: "What are you waiting for?".*

A. Kabanov *(an engineer of the Kharkov Turbine Plant): - By 3 p.m. of April 25, we were ready to conduct the tests. We had to check vibration at different rotation speeds. Comrades from "Dontekhenergo" were preparing to their own tests. They interfered with ours.*

Witness G. Dik, *the Chernobyl NPP chief shift manager: - A local critical mass emerged in the reactor that resulted in its runaway on prompt neutrons. Channels were ruptured. Steam entered the reactor space, torn construction "E" up and then hydrogen exploded. The Governmental Commission made its conclusion that the personnel should be blamed. I do not agree with that...*

The presiding judge (interrupting him): *- We did not invite you here as an expert on conclusions of the Governmental Commission.*

Witness Dik *(alters the topic but then returns to it again): - The reactor was prepared to the explosion by its previous operational history. I think, that while operating at low power, the reactor enters a nuclear-unsafe state. The Regulations have not ever mentioned that in the case of insertion of only 15 adsorbing rods into the active core, the apparatus enters a nuclear-unsafe state.*

We were absolutely unaware of the risks, associated with the reactor's physics... Nobody knew about risks of operating the reactor at low power... If a man does not know about risks, he will follow the test program strictly.

The prosecutor: *- Did the Regulations specify earlier, that, at the reactivity margin under 15 rods in the active core the reactor should be shut down?*

The witness: *- I have forgotten the old Regulations. Now, after the accident we have new ones.*

The prosecutor: *- What a training! (lifting his hands in surprise).*

An expert: *- You said that a local critical mass emerged in the reactor. Are there facts that confirm that?*

Witness Dik: *- RBMK was designed with deviations from the nuclear safety norms, it has a positive void effect. It resulted in the reactor runaway. Such a thing should not have happened according to all physics manuals.*

The expert: *- If local automatic regulators would have been operational, could the critical mass emerge?*

Dik: *-LARs have no connection with the matter. They are located above the active core, not beneath it. The void effect always existed in the reactor. But when the rods were moved up, they shifted the neutron field and a critical mass emerged below.*

Witness I . Kazachkov, *the former chief shift manager of Unit 4*

Kazachkov - *We did not know that the reactor enters a nuclear-unsafe state if reactivity margin in the active core falls under 15 OCR.*

The prosecutor: *- Could such consequences emerge if the personnel would have complied with the Regulations' requirements?*

The witness: *- Apparently, yes. The reactor could explode even if the Regulations were fully complied with. It has a positive void effect. It might explode even in the case of a loop depressurisation.*

The expert: *- Are you able to say that, having reviewed causes of the accident you know its precise cause?*

Kazachkov: - *Yes, we reviewed. But we do not understand it completely. To review them closely, one need to take documents, a pencil... I think that the reactor of such type was set to explode earlier or later. It is a reactor with a positive power reactivity coefficient, that was not used by anyone else in the World.*

The presiding judge: *- But the reactor operated for many years.*

The witness: *- Now, additional safety measures are applied for the reactor. The positive void reactivity effect was reduced... However, in the previous state of apparatus of the Chernobyl NPP, Smolensk, Kursk and - maybe - Leningrad NPPs, they were under a permanent threat of explosion due to a high void reactivity effect.*

A witness, *the former Party Committee Secretary of the Chernobyl NPP* ***S. Parashin:*** *- I think that all foreign media outlets will state, that after this trial the Soviet public will be informed that the NPP personnel should be blamed for the accident. There is some personnel's guilt, but not of the scale the court stated. We operated nuclear-unsafe reactors. We did not know that they are explosion-prone.*

G. Reikhman, *the former chief shift manager of RS-2: - As for my impressions of RBMK, when I arrived at the Chernobyl NPP... before that I dealt with other installations...*

The presiding judge *(interrupting him): - We are not interested in impressions of RBMK.*

Reikhman *(talks on submarines and then returns to the topic): - The main threat of the reactor is in that it is nuclear-unsafe. In the course of the pre-trial interrogation I noted 6 causes that might result in the accident.*

Witness A. Kryat *(the chief of the Nuclear Physics Laboratory of the Chernobyl NPP): - I was familiarised with the scheduled tests at the Unit, associated with load reduction from 1600 to 300 - 200 MW thermal (it was a draft version). I expressed my objections and said that I would not agree to 300 - 200 MW thermal. The power should be in the range of 1000 to 700. The matter is - a power level under 700 MW causes decrease of the reactivity margin. In such a mode, Prism system operates poorly (the system that allows operators to control physical state of the reactor). I objected in the course of the meeting in Dyatlov's. I said that the reactor's control is lost at the power level of 200 MW…*

We produced a training manual for chief reactor control engineers (CRCEs). It is a bulky book, containing about 120 - 130 pages. The manual should be studied for a month, then candidates should undergo interviewing and exams. The manual covers reactivity-related issues extensively.

Defendant Kovalenko*: - Why then the Nuclear Safety Dept. had failed to introduce provisions on risks of operating the reactor at low reactivity margins into the Regulations, manuals, etc.?*

Kryat: *- That was apparently a fault of the whole science. Now, documents already admit that the reactor enters a nuclear-unsafe state if less than 30 rods are inserted into the active core. The apparatus has such negative features that it could have happened sooner of later.*

Witness N. Shteinberg, *the deputy Chairman of GAEN (after the accident he was the CE of the Chernobyl NPP)****:*** *- We knew that we operated a very unpleasant apparatus. We learned how to operate it, we adapted to its tricks and surprises, but we did not know that it had absolutely unforeseen modes.*

A defence lawyer: *- Were there design shortcomings of the reactor?*

Shteinberg: *- Yes, there were some.*

Bryukhanov's defender *- What could you say about Bryukhanov as a director [2]?*

Shteinberg *- I think, he is a prominent engineer.*

Witness N. Karpan, *the deputy CE of the Chernobyl NPP.*

The presiding judge *- What were your duties before the accident?*

Karpan *- I was in the position of the deputy chief of the Nuclear Physical Laboratory of the Nuclear Safety Dept. (NSD). However, in the day of the accident I was acting deputy chief of the Dept. on physics, who was on vocations.*

The presiding judge *- Did you ever observe malfunctions of SDS-5 system and other similar faults in operation of reactors of the Chernobyl NPP?*

Karpan - *In the course of the first criticality launch of Unit 4 in 1983, experiments revealed introduction of positive reactivity after insertion of control and safety rods into the core, in the initial seconds of their movement. These observations are reflected in the report on the first criticality of the Unit.*

The effect may be generated in the operational reactor as well, in the case of abnormal height distribution of the neutron field.

The presiding judge *- those were experiments, while I ask you about the operation. Did you notice anything wrong in operation of the SDS?*

Karpan *- I did not notice that in the course of operations.*

The prosecutor *- Why did not NSD representatives attend on April 26 and allowed to reduce the ORM under 15 rods in the transitional mode?*

Karpan *- There was a program at the NPP that allowed to estimate ORMs at a pre-set schedule of changing the reactor power. We always used the program in the course of different tests to choose optimal modes of power change in terms of active core poisoning, to avoid ORM falling under 15 rods. These functions were fulfilled by physicists of the Nuclear Physical Laboratory, who watched round the clock up to the complete shutdown of reactors. They always worked before units' shutdown for scheduled maintenance works and in the course of their re-launch after these works. On April 25, Anatoliy Chernyshev (an experienced CRCE in the past) was expected to watch and he was ready to do it. But the Unit shutdown was rescheduled to April 26, while when Chernyshev called the NPP at daytime of April 26, he was told that the tests had been completed and he was free. That means that the chief manager in charge of the tests did not provide clear information. So the question is not mine.*

Dyatlov *- So, who is guilty in the accident - the shift personnel, NSD or the reactor?*

Karpan *- Similarly to a large aircraft at low altitude, RBMK type reactor is dangerous at low power - when it is poorly managed and controlled. The reactor's operation at low power levels was not studied sufficiently. I think that the personnel did not have a clear understanding of the threats involved. However, should all operate strictly according to the program, the explosion would not have happened.*

THE EXPERTS' TESTIMONIES

Then, the experts expressed their considerations on causes of the accident (the text fully quoted from [1]).

What then were the conclusions, presented to the court by highly skilled specialists? The experts confirmed the causal link between personnel's actions and initiation of the accident. They demonstrated that the test program did not stipulate measures to ensure nuclear safety of the reactor.

All charges against the defendants were recognised as substantiated. They also made a serious conclusion: "The level of labour and technological discipline at the Chernobyl NPP did not meet requirements to NPP operations". They noted facts of concealment of accident-associated shutdowns of reactors.

There was another important conclusion as well: “In the course of commissioning of Unit 4, it was known that the design solution of the rundown system was not operationalized. Therefore, the unit should not have been commissioned”.

However, the experts confirmed the conclusions of the Governmental Commission on design flaws of RBMK. But they emphasised that the accident could not happen in the case of a due unit operation.

In one aspect, the experts disagreed with conclusions of the Governmental Commission that stated that the reactor power before the launch of the night experiment decreased to 30 - 35 MW thermal. Actually, the power had fallen to zero.

As we already noted, an important conclusion was made - that RBMK type reactors are not nuclear-unsafe.

A witness, *one of RBMK-1000 designers, a representative of NIKIET,* ***K. Polushkin****: - Such a reactor may be operated and operated safely. It is only necessary to operate it duly. The Regulations note that the apparatus generally has a negative void reactivity coefficient. However, if a positive void effect emerges, safety precautions should be made. The safety system ensures security, similarly, the SDS rods’ drop ensues shutdown of the reactor.*

Dyatlov: *- What a document specifies safety measures in the case of a positive void effect?*

Polushkin: *- Documents. Issues pertaining to the positive effect were considered in specialised reports.*

Rogozhkin: *- Why does the SDS efficiency depend on a reactivity margin?*

Polushkin: *- It is difficult to decouple the dependence by technical means.*

Rogozhkin: *- Who can answer the question whether the reactor is explosion-prone?*

Polushkin: *- It is not explosion-prone if operated correctly.*

The court’s question: *- Do the experts support the earlier conclusions of the Governmental Commission on the reactor flaws?*

The experts’ answer: *- The experts confirm some flaws of the reactor, particularly the positive void reactivity effect. In this connection, no provisions were provided for actions of operational personnel in such a situation. Design flaws of the control and safety system are also confirmed. However, they might cause the accident only in the case of efforts of the reactor-operating personnel.*

The court’s question: *- Did the Model Reactor Operation Regulations ensure its safety?*

The experts’ answer: *- The Model Regulations ensured safety, including safety in transitional and emergency situations. As for the accident in question, the matter is not associated with the Model Regulations, it is associated with personnel deviations.*

The court’s question: *- Could the reactor flaws cause the accident?*

The experts’ answer: *- These flaws do not explain wrong actions of the personnel. The reactor is not nuclear-unsafe if 15 neutron adsorber rods are* *inserted into the active core, while 30 rods protect the reactor from unauthorised personnel actions.*

The court's question: *- Is the reactor safe?*

The experts' answer: *- Presence of 26 to 30 rods in the active core compensates positive reactivity. RBMK type reactors may be considered safe.*

The court's question: *- Why did not documents of the Chief Designer and RBMK developers provide any physical and engineering substantiation for inadmissibility of operating the apparatus at power level under 750 MW thermal, with ORM of less than 15 rods in the active core?*

The experts' answer: *- Such explanations are not necessary. Otherwise the Regulations will become too bulky. The personnel is expected to be professional and to be well aware of all these matters. However, now, a provision on nuclear-unsafe modes is already incorporated into the Regulations.*

The court's questions: *- What documents contain a prohibition to remove rods from the active core?*

The experts' answer: *- The Model Technological Regulations of RBMK Operation is the key document that provides for the minimal number of rods. The Regulations specify that if less than 15 rods are inserted into the core, the reactor must be shut down.*

Dyatlov's question: *- Did the reactor meet the nuclear safety rules?*

The experts' answer: *- Yes. All the design solutions are fully accident-proof. None NPP was designed to meet the accident that had happened.*

An expert in Civil Defence, of the Colonel's rank, provided his conclusion [1]. He completely confirmed the conclusions of the State indictment against the defendants. He noted, that after the accident at the Chernobyl NPP, guidelines and recommendations on radiation protection of the personnel and the general population. He admitted that the NPP was equipped by a sufficient stock of radiation dose control monitoring and individual radiation protection gear by the facility had failed to use them to the full extent, notwithstanding that the already developed preventive measures for protection of the NPP personnel and the city residents would have ensured their efficient protection if duly implemented.

The court asked the expert:

- Was Bryukhanov obliged to remove the personnel from the NPP site and to evacuate families of the NPP workers from Pripyat?

The expert answered unequivocally:

- Yes, he was obliged to.

Bryukhanov made his remark in response:

- Radiation levels in Pripyat were not such to evacuate people.

The verdict

29. 07.1987

The Judicial Board on criminal cases of the Supreme Court of the USSR, has examined in the open session the criminal case against:

Bryukhanov Viktor Petrovich, date of birth - December 1, 1935, place of birth - the city of Tashkent, a citizen of the USSR, a Russian, expelled from the CPSU in connection with this case, with a higher education, married, awarded by orders of the October Revolution and the Labour Red Banner, by medals "For Valorous Labour in Commemoration of 100th Birthday of Lenin" and "Labour Veteran", working as the Director of the Chernobyl NPP, the place of residence before the arrest: Kievskaya oblast, Pripyat, 32/13 Lenina St., apartment 78, without prior criminal convictions,-

and

Fomin Nikolay Maksimovich, date of birth - May 21, 1937, place of birth - Novo-Ekonomicheskoye village of Krasnoarmeiskiy district of Donetskaya oblast, a citizen of the USSR, a Russian, expelled from the CPSU in connection with this case, with a higher education, married, awarded by the Order of the Peoples' Friendship and by medals "For Valorous Labour in Commemoration of 100th Birthday of Lenin" and "Labour Veteran", working as the Chief Engineer of the Chernobyl NPP, the place of residence before the arrest: Kalininskaya oblast, Udomlya township, 26 Kurchatova St., ap. 47, without prior criminal convictions, -

who are both charged in committing crimes under art. 220 (para 2) and 165 (para 2) of the CC of the UkrSSR;

Dyatlov Anatoliy Stepanovich, date of birth - March 3, 1931, place of birth - Atamanovo village of Sukhobuzinskiy district of Krasnoyarskity krai, a citizen of the USSR, a Russian, expelled from the CPSU in connection with this case, with a higher education, married, awarded by the Order of the Labour Red Banner, the Order of Honour and by medal "For Valorous Labour in Commemoration of 100th Birthday of Lenin", working as the deputy Chief Engineer on operations of the second stage of the Chernobyl NPP, place of prior residence: Kiev, 16-A Nikolaeva St., ap. 7, without prior criminal convictions,-

who is charged in committing a crime under Article 220 (para 2) of the CC of the UkrSSR;

Rogozhkin Boris Vasilievich, date of birth - August 7, 1934, place of birth - the city of Gorkiy, a citizen of the USSR, a Russian, expelled from the CPSU in connection with this case, with a higher education, married, awarded by medals "For Valorous Labour in Commemoration of 100th Birthday of Lenin" and "Labour Veteran", working as the chief shift manager of the Chernobyl NPP at the time of committing the crime, place of residence prior to the arrest: Kiev, 19 Verbitskogo St., ap. 186, without prior criminal convictions,-

who is charged in committing crimes under articles 220 (para 2) and 167 of the CC of the UkrSSR;

Kovalenko Aleksandr Petrovich, date of birth - February 2, 1942, place of birth - Aleksandrovskoye village of Tuganskiy district of Tomskaya oblast, a citizen of the USSR, a Russian, a non-party, with a higher education, married, with a dependent underage son, awarded by medal "For Valorous Labour in Commemoration of 100th Birthday of Lenin", working as the chief manager of Reactor Section # 2 of the Chernobyl NPP, place of residence: Kiev, 15-A Nikolaeva St., ap. 68, without prior criminal convictions,-

who is charged in committing a crime under Article 220 (para 2) of the CC of the UkrSSR;

Laushkin Yuriy Alekseevich, date of birth - April 10, 1937, place of birth - the city of Tambov, a citizen of the USSR, a Russian, a non-party, with a higher education, married, working as an inspector of the State Committee of the USSR for Nuclear Power Supervision at the Chernobyl NPP at the time of committing the crime, place of residence before the arrest: Kiev, 11 Verbitskogo St., ap. 227, without prior criminal convictions,-

who is charged in committing a crime under Article 167 of the CC of the UkrSSR.

Having heard testimonies of the defendants and the witnesses, having examined and assessed experts' conclusions, as well as documentary and other evidence, adduced to the case file materials, having heard statements of the state prosecutor, defence lawyers and the last pleas of the defendants, the Judicial Board on criminal cases of the Supreme Court of the USSR,

has found that:

On April 26, 1986, at about 01:24, an accident had happened at Unit 4 of the Chernobyl NPP - a thermal explosion destroyed the active core of RBMK-1000 reactor and building construction of the said Unit; radioactive substances were released to the atmosphere and onto large adjacent areas. As a result of the accident, 30 persons had died from injuries and acute radiation sickness, radioactive radiation inflicted grievous and less grievous bodily injuries to a substantial number of persons. Residents were evacuated from many settlements in the 30-km exclusion zone around the NPP. The material losses inflicted to the state and citizens exceeded 2 billion roubles.

The main causes of the accident include gross violations of the rules set to ensure nuclear safety at a potentially explosion-prone facility - the nuclear power plant, that were made by personnel of the Chernobyl NPP - by the Director Bryukhanov V.P., the Chief Engineer Fomin N.M., the deputy Chief Engineer on operation of 2nd NPP stage

Dyatlov A.S., the chief manager of the Reactor Section Kovalenko A.P., the chief NPP shift manager Rogozhkin B.V. and others.

The state inspector of the State Committee of the USSR for Nuclear Power Supervision at the Chernobyl NPP Laushkin Yu.A. fulfilled his service duties with criminal negligence, he failed to ensure a due control of the personnel's compliance with the nuclear safety norms and rules, he failed to take necessary measures for suppression and prevention of such violations at the Chernobyl NPP.

Specifically, criminal actions of the defendants included the following [3].

Due to faults of the top managers of the NPP - the Director Bryukhanov V.P. and the Chief Engineer Fomin N. M. - training of the NPP personnel did not meet requirements of the Personnel Management Guidelines, approved by the Ministry of Power Industry of the USSR on April 16, 1982. A Training and Methodological Council was not established at the NPP to enhance skills of engineers and technical personnel and to provide professional training of workers, that, according to para 1.6 of the "Guidelines..." should address many important issues, associated with personnel training organisation and methodologies: to generalise personnel training experience, to develop measures for improvement of organisational arrangements and quality of professional training and theoretical training sessions, to address other issues, pertaining to in-house training and refresher training of workers, engineers and technical personnel. A TC or a Training Facility was not established at the plant. In violation of papa 2.2.22 and 2.2.24 of the Guidelines, the NPP top managers had not compiled lists of positions for training, back-up work and independent work of persons who were for the first time appointed on positions of chief shift managers of NPP sections and units, and on positions of their deputies. According to an order of Bryukhanov, people were examined by insufficiently competent boards, that - in addition - were not chaired by the NPP top managers. At the NPP, the requirement of para 7.2 of the Guidelines was not complied with as well (the one pertaining to systematic inspection rounds of workplaces to be conducted by the NPP top managers at least monthly, and registration of outcomes of all these inspection rounds in the relevant log). Bryukhanov, Fomin and Dyatlov distanced themselves from these works. All these factors degraded responsible attitudes of the NPP personnel to compliance with labour and technological discipline, shift personnel had poor knowledge, their knowledge was not supported by relevant practical experience - as a result, deviations from the due technological discipline often happened, that resulted in numerous accidents and shutdowns of reactor units even before April 26, 1986.

Bryukhanov, Fomin and Laushkin, in violation of requirements of the Instruction Manual on Investigation and Registration of Accidents (approved by the Ministry of Power Industry of the USSR on September 17, 1975 and September 1, 1983), failed to ensure full registration, comprehensive and technically sound investigation of causes of accidents and other serious deviations from the operation mode. Relevant causers were not always identified; in some cases, causes and even facts of the violations were concealed.

In its prescription protocols the State Committee of the USSR for Nuclear Power Supervision many times demanded the NPP top managers to remediate non-compliance with the due technological discipline, nuclear safety standards and rules. These protocols also highlighted poor professional training of the operational personnel, but - due to faults of the defendants - the due measures were not taken to remediate the deficiencies. Defendant Laushkin, who served from 1982 as a State Inspector of the State Committee of the USSR for Nuclear Power Supervision ("GAEN" after 1985) at the Chernobyl NPP, fulfilled his service duties with criminal negligence. He failed to ensure a due control of compliance with the established standards and rules of safe operation of potentially explosion-prone nuclear power installation. He conducted inspections superficially, rarely visited workplaces, failed to identify many violations of the personnel; he tolerated a poor technological discipline, and negligent attitudes of the NPP personnel and its top managers to compliance with the due nuclear safety standards and rules. As a result of such attitude of Laushkin to his service duties, an atmosphere of lack of control and irresponsibility established at the NPP, allowing grave violations of the due safety norms to be left unidentified and unprevented. Only in the period from January 17 to February 2, 1986, at Unit 4 of the Chernobyl NPP, automatic reactor safety systems were disabled six times without authorisation of the Chief Engineer, that is a serious violation of Chapter 3 of the Technological Regulations of Operation of the Chernobyl NPP reactor units. Defendant Laushkin, did not respond to these violations as the State Nuclear Safety Inspector.

Irresponsible attitudes of Laushkin, the NPP personnel and its top managers to matters of ensuring nuclear safety, in combination with insufficient professional training of the operational personnel of complex power installations had eventually caused the accident of April 26, 1986.

Notwithstanding that necessary tests of turbine generator were not completed at Unit 4 of the NPP, on December 31, 1983, Bryukhanov had signed the commissioning protocol of the minimal operational configuration of Unit 4 as a completely fit one. In 1982 - 1983, in order to make the unit safety system fully operational, under a contract with

“Dontekhenergo” organisation, tests of the turbine generator were conducted in the combined rundown mode with in-house load - the tests failed and were not completed. Nonetheless, on October 30, 1985, Fomin, Kovalenko and Dyatlov adopted a Technical Solution and ordered to put the rundown mode at Unit 4 into pilot operation, without notifying the superior organisations on the tests to be conducted in the course of a regular shutdown of the Unit for maintenance repairs. According to the schedule, Unit 4 was to be shut down on April 25, 1986 for 40 days of scheduled maintenance repairs. Prior to the Unit shutdown, a next test of TG-8 was to be conducted in combined rundown mode with in-house load, as well as some other tests. The test works program was drafted by the chief test team engineer of “Dontekhenergo” Metlenko G.P., who did not have necessary knowledge and experience of operating nuclear reactors. Bryukhanov, Fomin, Dyatlov and Kovalenko did not review the program with due diligence, notwithstanding that it provided for substantial deviations from the Technological Regulations. Notwithstanding that, Fomin, Dyatlov and Kovalenko signed it. It was the program, that was followed by the personnel later in the course of the tests that resulted in the accident of April 26, 1986. By their nature, the planned tests necessitated (according to para 19.4.1 of RBMK-1000 Control Manual) involvement of a representative of the Nuclear Safety Dept., but the presence was not stipulated and had not been ensured.

The test program had to be agreed with the Scientific Supervisor, the Chief Designer, “Gidroproekt”, GAEN and the deputy NPP CE on science, but it was not made.

Fomin, Dyatlov and Kovalenko did not stipulate the reactor’s shutdown by the moment of the launch in the test program, allowing the operational personnel to disable shutdown system SDS-5 on disconnection of two turbines, they did not dovetail the reactor’s thermal power to the generator’s electric power; they failed to provide for release of excessive steam from the loop; they failed to provide for due measures for automatic or manual compensation of swift reactivity changes in the course of the experiment. In violation of para 1.10 of the Regulations, without any coordination and technical substantiation, Fomin, Dyatlov and Kovalenko allowed installation and connection of an unauthorised control unit at the Unit 4 Control Panel - so called “MCA button”, that altered the standard circuit, associated with ensuring nuclear safety for the period of the experiment and substantially reduced safety of operation of the reactor unit. Bryukhanov, Fomin and Laushkin did not control organisation of preparatory works of the test, they were not present in the course of the tests conducted.

Dyatlov, who was responsible for the tests, authorised inexperienced CRCE Toptunov and the unit shift manager Akimov to conduct the experiment. The NPP chief shift manager Rogozhkin did not supervise the tests. While knowing that on 26.04.86, tests were to be conducted at Unit 4 with a test run of TG-8 in rundown mode with in-house load, Rogozhkin, in violation of para 5.3; 5.4; 5.8 of his job description, authorised conduction of the tests without even reviewing the test program, notwithstanding that the program failed to provide for real measures to ensure nuclear safety, he did not control personnel's preparedness to the tests; he did not control compliance with the program and the Technological Regulations in the course of the tests.

Repeated delays of the scheduled tests resulted in haste in the personnel's work and in conduction of the tests in the night hours. At 23:10 of April 25, 1986, the NPP personnel started to conduct the tests and to reduce thermal power of the Unit. At 00:28 of April 26, in the course of reduction of the reactor power under the minimal level as set in the program (700 MW), at transition to local to global power control mode, due to the operator's fault, the power level decreased to zero for several minutes. By 01:06, the power was increased only to the level of 200 MW, instead of 700 MW as the program stipulated. In the course of doing it, the minimal necessary reactivity margin in the active core was not ensured - as a result, the reactor control was substantially complicated and its safety was compromised. In such a case, the reactor should be shut down, but the personnel did not do it. The reactor also was not shut down - as it should be done - before the launch of the tests, while the automatic shut down system was disabled by erroneous actions of the personnel. At 01:23:04, turbine steam valves were closed, and the turbine generator rundown test with in-house load was launched.

In connection with growing steam fraction in reactor channels, growing reactivity, instability of the reactor, vibration of pipelines and equipment, at 01:23:40, the operational personnel activated the shutdown system manually. At that time, positive reactivity raised in the reactor, that caused its swift runaway - growing power output of the reactor, heating of the fuel and a thermal explosion. The explosion destroyed the active core of the reactor and its constructions. A fire emerged that was extinguished for more than 2 hours. The accident and the subsequent fire killed the chief operator Khodemchuk V.I. and maintenance engineer Shashenok V.D.

Besides the above violations of the Regulations and other rules of operating nuclear power installations, that were committed by Bryukhanov, Fomin, Dyatlov, Kovalenko, Rogozhkin and Laushkin, defendant Dyatlov - who was the chief manager in charge of the tests being conducted at the NPP - also committed a range of other violations that - similarly to the above mentioned ones - directly influenced development of the emergency situation and the accident. Being the direct chief manager of the test, he was obliged to familiarise the personnel involved into the test with the working program and the schedule of the test, but he failed to do it duly and did not define a specific sequential order of actions of the personnel. The test under his management was conducted in a hurry, in presence of idle workers of previous shifts.

Dyatlov failed to provide a technical substantiation for and failed to agree with the deputy Chief Engineer of the NPP on science the discharge of excessive steam from the reactor and connection of all MCPs to the reactor. On his order, at 2 p.m. of April 25, 1986, the Emergency Core Cooling System of the reactor was disabled and was not enabled later, that was a gross violation of requirements of para 30.5 Technical Operation Rules, para 2.10.5 and Chapter 3 of the Regulations. While knowing that at several minutes past midnight of April 26, 1986, the reactor unit operated with unacceptably low reactivity margin (less than 26 rods),in violation of requirements of Chapter 9 of the Regulations, Dyatlov did not take measures to remediate the violation. At 00:30 of the same day, in presence of Dyatlov, CRCE Toptunov, due to his insufficient experience, reduced power level of the reactor down to zero, that resulted in xenon "poisoning" of the reactor, after which, following instructions of Dyatlov who deviated from requirements of the Regulations (that stipulated immediate shutdown of the reactor in such a case), he started to raise its power without a minimal reactivity margin. About 10 minutes later, another gross violation of Chapter 3 of the Regulations was made according to Dyatlov's instructions - the shift personnel disabled SDS-5 safety system on a range of parameters.

In deviation from para 2.1 of the test program, Dyatlov ordered to conduct the test at the reactor's power level of 200 MW, instead of 700 to 1000 MW, deemed necessary for its safe operation.

According to conclusions of the forensic engineering experts, the said violations cumulatively resulted in intensive vaporisation in the active core of the reactor, emergence of positive reactivity and uncontrolled runaway of the reactor on prompt neutrons and then to a powerful thermal explosion at Unit 4 of the NPP.

Having realised the scale and the nature of the accident of April 26, 1986, Rogozhkin, being the chief NPP shift manager, had to fulfil (but actually had failed to fulfil) requirements of para 3.2.3 of the Action Plan for Protection of the NPP Personnel and Residents the NPP Zone - he had failed to activate the system of accident notification alert. In violation of para 8.11; 49.16; 49.18 Technical Operation Rules, Rogozhkin did not manage the accident mitigation works, he did not coordinate actions of the shift personnel and specialised services - as a result, the firefighters who did not know about the radiation intensity and did not apply relevant precautions, started to extinguish fire sources in close proximity to the destroyed reactor. Firefighters Pravik, Kibenok, Tishura, Ignatenko, Vaschuk and Titenok were exposed to high radiation doses and died later from acute radiation sickness. Due to Rogozhkin's faults, the NPP shift personnel were not removed timely to a safe zone, as a result, many workers got high radiation exposure doses. Bryukhanov, who arrived at the NPP at about 2 a.m. and had reliable information on substantial radiation levels at the NPP site as the NPP Director, failed to set the [emergency] mode of conduct at the NPP, and failed to activate the Action Plan for Protection of the NPP personnel and the general population.

At 8 a.m. of April 26, 1986, notwithstanding a grave radiation situation, the new shift personnel in full force was admitted to the NPP withe the knowledge of Bryukhanov, while there was not a need to do it. When Bryukhanov had got information that in some places of the NPP radiation levels exceeded 200 R/hour (2 Sv/hour), pursuing his personal interests (to make the situation appear safe), he deliberately concealed these facts; and - abusing his official position - submitted information with patently underestimated radiation levels to superior competent bodies. Bryukhanov's failure to provide a broad and adequate information on the nature of the accident resulted in adverse impacts on the NPP personnel and the general population of adjacent areas. Besides Khodemchuk and Shashenok, who had died, other 28 persons got high radiation exposure doses and died from acute radiation sickness in May - June 1986. In addition, many other persons who were exposed to radiation, suffered bodily injuries of different severity. At the court session, defendants Bryukhanov, Fomin and Dyatlov pleaded partially guilty in the charges against them, while Rogozhkin, Kovalenko and Laushkin pleaded not guilty.

The main causes that resulted in the accident are associated with blatant non-compliance with the rules set to ensure nuclear safety at a potentially explosion-prone facility - a nuclear power plant, the violations of the Chernobyl NPP personnel - the NPP Director Bryukhanov V .P., the Chief Engineer Fomin N.M., the deputy Chief Engineer on operations of the second NPP stage Dyatlov A.S., the chief of the NPP Reactor Section Kovalenko A.I., the chief NPP shift manager Rogozhkin B.V. and others.

The State Inspector of GAEN at the Chernobyl NPP Laushkin Yu.A. fulfilled his service duties with criminal negligence, he failed to ensure a due control of the personnel's compliance with the nuclear safety standards and rules, he failed to take necessary measures to prevent and eradicate such violations at the Chernobyl NPP.

Forensic engineering experts have found that nuclear reactors and RBMK-1000 reactor installations become potentially explosion-prone in the case of non-compliance with standards and rules that regulate their operation.

The Judicial Board founds that the information of leading scientists-physicists, conclusions of the Governmental Commission and forensic engineering experts on causes of the accident coincide, and their scientific substantiation and correctness are of no doubts.

The guilt of defendants Bryukhanov, Fomin, Dyatlov, Rogozhkin and Kovalenko in on-compliance with the rules set to ensure safety at a potentially explosion-prone facility - a nuclear power plant, that entailed human casualties and other grave consequences, is additionally confirmed by documentary evidence incorporated into the case file materials, as well as by testimonies of witnesses and victims.

The fact that, on April 25 - 26, 1986, Unit 4 reactor was operated with the operational reactivity margin of less then 26 rods, is confirmed by entries in operational logs of Unit 4 chief shift manager and CRCE, that were examined at the court session, as well as by a photo-copy of the print-out of “Skala” Centralised Control System - according to the latter, at 01:22:30 of April 26, 1986, the reactivity margin reached 6 to 8 rods. According to another instrument - SFKR recorder - at 00:28 of April 26, 1986, the reactor’s power initially decreased to zero and then increased to 180 to 200 MW. It was made in violation of para 6.2 of the Regulations, without the poison override, without a minimal necessary reactivity margin.

The non-compliance of Dyatlov, Rogozhkin and the shift personnel with requirements of the Regulations in the course of the tests at Unit 4 is confirmed by entries in the CRCE’s operational log and by his written testimony that after the shift take-over he was instructed to reduce the reactor’s power, failed to maintain control and decreased the reactor’s power to zero. Later on, the reactor’s power was increased to 200 MW, and that was the power level at which the test was launched. An Akimov’s entry also confirms that the automatic safety system SDS-5 was disabled.

In the course of pre-trial investigation and at the court session, defendant Dyatlov insisted that the main cause of the accident is associated with design flaws of RBMK-1000 reactor and its safety systems. These claims are refuted by conclusions of the forensic engineering experts, the Governmental Commission and by the above evidence. Moreover, there is additional evidence against these claims. In particular, witnesses Kryat and Karpan testified that in the course of their dealing with RBMK-1000 reactors of the Chernobyl NPP, they - as specialists on nuclear safety matters - had not ever observed any deviations in operation of the reactors and SDS-5.

Compliance with requirements of the Technological Regulations completely ensures safe operation of the reactor installations. Similar testimony on these matters were also provided by other witnesses - leading specialists Polushkin and Gavrilov.

As it was found in this case, reactor installations with RBMK-1000 reactors have some design deficiencies; the investigation bodies have initiated a separate criminal case against persons who failed to take timely measures to improve their design.

Accounting for the above considerations, the Judicial Board finds that defendants Bryukhanov, Fomin, Dyatlov, Rogozhkin and Kovalenko are guilty in non-compliance with occupational and technological discipline and the rules ensuring operational safety at a potentially explosion-prone facility, that entailed human casualties and other grave consequences - i.e. guilty in committing a crime under para 2 of Article 220 of the Criminal Code of the UkrSSR, and Laushkin is guilty in undue fulfilment of his service duties as a result of his careless attitude to them, that entailed substantial damage to interests of the state and to legislatively protected rights and interests of individuals - i.e. guilty in committing a crime under Article 167 of the Criminal Code of the UkrSSR.

The guilt of Bryukhanov in abuse of office and the guilt of Rogozhkin in criminal negligence are confirmed by evidence items of the investigation - (Bryukhanov's confession on his failure to activate the Plan and witnesses' testimonies).

Being aware of the actual radiation situation, Bryukhanov, pursuing his personal interests to make the situation at the NPP and around it appear safe after the accident, and abusing his official position, submitted information to Kievskaya oblast Committee of the Communist Party of Ukraine and to other competent bodies that contained patently false underestimated radiation intensity data, namely specifying that maximal radiation exposure levels were found to reach up to 1000 μR/sec (36 mSv/hour) at the NPP site, and from 2 to 4 μR/sec (0.07 - 0.14 mSv/hour) in Pripyat.

The fact that Bryukhanov and Rogozhkin are guilty in the failure to take timely measures for protection and evacuation of the NPP personnel and the general population of the adjacent zone, is also confirmed by conclusions of the technical expert examination on civil defence matters.

The Judicial Board assesses these consequences as grievous.

Accounting for the above considerations, the court finds that defendant Bryukhanov is also guilty in abuse of office entailing grievous consequences - i.e. in committing a crime under para 2 of Article 165 of the Criminal Code of the UkrSSR, and that Rogozhkin is guilty in undue fulfilment of his service duties as a result of his careless attitude to them, that entailed substantial damage to interests of the state and to legislatively protected rights and interests of individuals - i.e. guilty in committing a crime under Article 167 of the Criminal Code of the UkrSSR.

In the course of assignment of punishment of the defendants, the Judicial Board was guided by Article 39 of the Criminal Code of the UkrSSR and accounted for the fact that non-compliance of Bryukhanov, Fomin, Dyatlov, Rogozhkin and Kovalenko with the due operational and technological discipline and nuclear safety rules entailed the consequences that are correctly called disastrous.

Accounting for the above considerations and in accordance with Article 43 of Fundamental Principles of Criminal Justice of the USSR and Republics of the Union, articles 323, 333 and 335 of the Criminal Procedure Code of the UkrSSR, the Judicial Board of the Supreme Court of the USSR

has ruled:

To adjudge Bryukhanov guilty in committing a crime under para 2 of Article 220 and para 2 of Article 165 of the Criminal Code of the UkrSSR; Fomin, Dyatlov and Kovalenko guilty in committing a crime under para 2 of Article 220 of the Criminal Code of the UkrSSR; Rogozhkin in committing a crime under para 2 of Article 220 and Article 167 of the Criminal Code of the UkrSSR; Laushkin in committing a crime under Article 167 of the Criminal Code of the UkrSSR.

THE CONCLUSION

From the official communication - "In the Politbureau of the CPSU Central Committee" - published in "Pravda" Newspaper on July 20, 1986 [1]:

"The Chairman of State Committee for Nuclear Power Supervision Kulov, the deputy Minister of Power Industry and Electrification of the USSR Shasharin, the first deputy Minister of Medium Machine-building Industry of the USSR Meshkov, the deputy Director of the R&D Institute Emelyanov were discharged from their official positions for major faults and drawbacks in their performance that resulted in an accident with grievous consequences. In addition, they were issued serious Party reprimands. The former Director of the Chernobyl NPP Bryukhanov was expelled from the Party".

The Party Control Committee under the CPSU Central Committee reviewed issues pertaining to responsibility of high officials of some ministries and agencies, that were guilty in the accident at the Chernobyl NPP.

The Chief of "Soyuzatomenergo" Indusial Association of the Ministry of Power Industry, a CPSU member, Veretennikov G.A. and the Chief of a Directorate General of the Ministry of Medium Machine-building, a CPSU member Kulikov E.V. were found to work in an irresponsible manner in the sphere of ensuring reliable operation of NPPs, and to manage their subordinate organisations poorly. They also made serious mistakes in personnel management. The Party Control Committee under the CPSU Central Committee expelled Veretennikov G.A. and Kulikov E.V. from the Party.

Some responsible officials were issued serious Party reprimands.

The author's comments

Many people, who attended the court sessions or reviewed investigation and court materials later, felt that results of the investigation of causes of the Chernobyl accident were "contracted". Such an assumption may be supported by a short list of questions that emerged while I drafted this report.

1. Why did they include representatives of the organisations that designed the nuclear-unsafe reactor into the list of forensic engineering experts?

Experts *- members of the forensic engineering expert team were appointed by a decision of the chief investigator, a Senior Assistant of the Prosecutor General of the USSR, a State Counsellor in Justice 3rd Class, Potemkin Yu.A. on September 15, 1986 (Criminal Case # 19 -73, pp. 31 - 38 v.38):*

- *Dolgov V.V.- a laboratory chief of Moscow Physical Power Industry Institute, Cand. Sci. (Engineering);*
- *Krushelnitskiy V.N.- the Chief of 2nd Directorate of GAEN of the USSR;*
- *Martynovchenko L.I.- the Chief of the Southern District Inspectorate at Kursk NPP;*
- *Minaev E.V.- a deputy Chief of the "Glavgosekspertiza" of the USSR State Committee for Construction;*
- *Mikhan V.I.- a department chief of NIKIET, Cand. Sci. (Engineering);*
- *Neshumov F.S. - a department chief of "Glavgosekspertiza" of the USSR State Committee for Construction;*
- *Nigmatulin B.I.- a department chief of VNIIAES, Doct. Sci. (Engineering);*
- *Protsenko A.N.- a laboratory chief of IAE, Doct. Sci. (Engineering);*
- *Solonin V.I.- Professor, the Chair of Power Industry Machines and Installations of Moscow High Technical School, Doct. Sci. (Engineering);*
- *Stebok I.A.- a deputy department chief of NIKIET;*
- *Khromov V.V.- a chairholder of Moscow Physical Engineering Institute, Doct. Sci. (Physics and Mathematics)*

Note: Solonin V.I. was also a deputy chairholder of E-7 chair of Bauman Moscow High Technical School, i.e. a deputy of N.B. Dollezhal. Another expert - Mikhan V.I. - was a Professor of the same chair.

So, from the list of 11 experts, three persons represented the Chief Designer, while one person (Protsenko A.N.) represented the Scientific Supervisor.

2. Why none of the experts represented organisations that operated RBMK-1000?

The informed ones will never assume that Nigmatulin B.I., a department chief of VNIIAES, may be considered as a representative of an operating organisation.

At the same time, the deputy Minister of Power Industry Shasharin G.A. may be recognised to represent reactor operators. And his verdict was unequivocal - RBMK reactors are explosion-prone. Shasharin's conclusion was "encouraged" - on July 20, 1986 he was discharged (see "Pravda" Newspaper: *"... the deputy Minister of Power Industry and Electrification of the USSR Shasharin ... were discharged from their official positions for major faults and drawbacks in their performance that resulted in an accident with grievous consequences...")*.

Shasharin was not the only man who insisted on the truth. He himself described political manipulations in the course of investigation of the accident ("Chernobyl: Duty and Courage", compendium, v. 1, Moscow, 2001) in the following way: "The Protocol on causes of the accident was not signed by three persons: by me, by the Director of the USSR R&D Institute of NPP Operation Abagyan A.A. and by the Chief Engineer of "Soyuzatomenergo" Industrial Association of the USSR Ministry of Power Industry Prushinskiy B.Ya., who was responsible at that time for NPP operations. In parallel, I chaired the Commission of the USSR Ministry of Power Industry. We signed another Protocol of that Commission. The latter Protocol was classified and kept out of public discussion. While the Protocol did not provide a complete quantitative proof, but in qualitative terms, the Protocol demonstrated that the main causes of the accident were associated with faults in design of the control, adjuster and safety rods (the SDS) and designer's errors in assessment of the void reactivity effect.

Naturally, such conclusions changed the key causers, but the operators including me (I dealt with NPP operational issues at the level of a deputy Minister) did not thought about the guilty ones at that time. Actually, all persons who dealt with the nuclear power industry should be blamed, but not the operational personnel, by no means. I am absolutely convinced that nobody was guilty in terms of criminal justice, and even if some persons could be blamed, the operational personnel could not. But they had been prosecuted swiftly and cruelly.

The trial was swift and they heard only those witnesses who shared the official version of causes of the accident.

Initially, before my discharge, I tried to take some steps to make the Report contain at least a some part of the truth, but I was not allowed to. By that time, I had been already discharged. When I read the Report later I felt shame, as even its estimates and considerations failed to explain the scale of the disaster, while any specialist in the sphere could easily see manipulations with data.

I applied to the Commission's Chairman of the Politbureau of the CPSU Central Committee, to the USSR Prime Minister N.I. Ryzhkov (the letter was classified), that it is impossible to conceal the truth on causes of the accident, that it is a criminal act and the truth would inevitably emerge, sooner or later".

3. The forensic engineering experts recognised the reactor, that was constructed and assembled with application of standard equipment items (not explosion-proof ones) to be explosion-prone, albeit with some reservations. Why?

"Any nuclear reactor becomes explosion-prone in some modes of operation, in the case of operational and control violations. In the case of the said violations, power output increases and - after some time- it exceeds the heat take-off capacity.

The imbalance of heat release and heat removal results in rise of coolant's parameters, overheating of fuel assemblies and construction elements of the reactor, that - if it is impossible to terminate the chain fission reaction - may result in a thermal explosion.

<u>A high energy release in the said case cannot be contained by technically appropriate safety systems</u>. Therefore, nuclear steam generators with RBMK, WWER and breeder reactors should be categorised as potentially explosion-prone.

Nuclear power installations are also prone to generation of hydrogen, and its concentrations may reach explosive levels, should the technological process of operation of nuclear power installations and hydrogen level control be violated.

Nuclear power installations incorporate numerous equipment items that operate at a high pressure. In the case of inadmissible increase of media pressure, deterioration of metal quality or defects in the metal, an explosion also becomes possible.

Therefore, nuclear reactors and reactor installations are potentially explosion-prone in the case of non-compliance with standards and rules that regulate quality of manufacture of equipment, assembly and operation of the installations.

Rogozhkin: *- Who can answer the question whether the reactor is explosion-prone?*

Polushkin: *- It is not explosion-prone if operated correctly.*

The experts could not state clearly and unequivocally that "RBMK is explosion-prone" even after its explosion. They could not state that as such a conclusion clearly indicated that the reactor does not meet GSP and NSR requirements. So, if the reactor does not meet safety rules, the experts would had to blame the reactor designers for the explosion - i.e. to blame themselves. As a result, a crafty statement was invented - "It is not explosion-prone if operated correctly". At the same time, they do not add that the operation-related documents provided by the reactor designers to NPP personnel, were absolutely silent about possible dangerous modes of RBMK type reactors.

The court's question: *- Why did not documents of the Chief Designer and RBMK developers provide any physical and engineering substantiation for inadmissibility of operating the apparatus at power level under 750 MW thermal, with ORM of less than 15 rods in the active core?*

The experts' answer: *- Such explanations are not necessary. Otherwise the Regulations will become too bulky. The personnel is expected to be professional and to be well aware of all these matters. However, now, a provision on nuclear-unsafe modes is already incorporated into the Regulations.*

The court's questions: *- What documents contain a prohibition to remove rods from the active core?*

Dyatlov's question: *- Did the reactor meet the nuclear safety rules?*

The experts' answer: *- Yes. All the design solutions are fully accident-proof. None NPP was designed to meet the accident that had happened.*

The Chief Designer and the Scientific Supervisor failed to foresee all possible emergency situations at the reactor, including the ones that might emerge in the process of changes of its core composition. When, later on, in the course of RBMK operation, some dangerous changes of its physical properties were revealed, the developers failed to take timely measures for enhancement of its nuclear safety. Therefore, being direct participants on the forensic engineering experts' team, they could not admit that the reactor is nuclear-unsafe even after initiation of an uncontrolled chain reaction in the reactor - in such a way they would admit their own guilt.

The author's conclusions

According to requirements of the USSR Nuclear Safety Rules, RBMK type reactors should be designed, manufactured and commissioned to operational personnel absolutely explosion-proof. As such, it was promoted everywhere by the Institute of Atomic Energy (the Scientific Supervisor of the reactor project) and NIKIET (the Chief Designer). As a result, even after the accident with explosion of the reactor, representatives of these institutes continued to insist that the reactor is nuclear-safe, but it has some "specifics".

Such "specifics" manifested themselves many times at different NPPs equipped by RBMK type reactors. In particular, in 1975, an accident happened at the Leningrad NPP that was close to the point of a similar explosion. Some part of the active core was damaged. After the accident, the amount of radioactive releases from the NPP was many times higher than in the case of infamous and globally known Three Mile Island NPP (US). A commission of IAE specialists analysed the situation and developed a list of recommendations to improve reliability of the reactor, including measures to reduce the void reactivity effect and to design an efficient rapid response SDS. However, the Chief Designer started to implement these recommendations only after the Chernobyl accident. They needed a disaster to start replacement of rods in the reactor! Nothing prevented the Scientific Supervision of RBMK project Academician A.P. Aleksandrov and the Chief Designer Academician N.A. Dollezhal to remediate their errors after the accident at the Leningrad NPP. They had 10 years for these purposes. Who, then, is the real author of the Chernobyl disaster? Chernobyl "injustice system" initiated a criminal case against them, but it was worded in a strangely sounding way - "the criminal case against persons who failed to take timely measures to improve the reactor design". Investigation authorities proceeded the case as a separate one. Naturally, nobody was convicted under the latter case, as academicians and "Heroes" are not triable in our country. The case against RBMK developers was closed relying on conclusions of "puppet" engineering experts that its technical control and safety means ensured safe operation of the reactor if the Regulations were duly complied with. The NPP personnel remained the only collective causer of the accident.

Western journalists who were present at the court sessions quickly realised that the responsibility for the global-scale disaster was shifted from real causers - from high levels of Soviet nuclear industrial complex and their associates in the sphere of public health and environment to "scapegoats". One of them ironically said: "In the Soviet court, a defendants' bench is too short".

For comparison: in the case of Three Mile Island NPP reactor its designers and manufacturers had never attempted to blame the NPP personnel for the accident of April 28, 1979. They understood that designers "may analyse the first minute of an accident for hours and even weeks, seeking to understand what happened or trying to project what will happen next of parameters are manipulated", whereas an operator has to deal with "hundreds of thoughts, decisions and actions he takes during a transient". But in the best way the thought was formulated by the NPP operator E.R. Frederick who was on duty at the night of the accident, he told the court that **"... an operator must never be**

placed in a situation which an engineer has not previously analysed. An engineer must analyse a situation without observing an operator's reaction to it". After these words, the US court acquitted him - an unthinkable option for the "Chernobyl" court.

Let us leave aside "specifics" of our justice system. Before the accident at the Chernobyl NPP, RBMK type reactors were universally considered good without any reservations. As a result, engineers and designers - assuming the reactor to be non-explosive - installed the coolant pipes (multipass forced circulation circuit) within the accident containment system, while the reactor itself was built without a pressurised enclosure. All were convinced that RBMK type reactors are absolutely safe, so there is no need to enclose them into containments. In such a way they saved people's money, moreover, there was no need to spend money for no purpose as "a high energy release ... cannot be contained by technically appropriate safety systems". As a result, the reactor was completely destroyed while its accident-containment systems remained intact and almost were not contaminated by radioactive substances - the systems intended to "limit spread of accident-generated radioactive substances within the NPP and their releases into the environment". The explosion generated the maximal possible release of radioactive substances (including the active core contents) to the air - at least 80% (instead of 5% in the case of installing the reactor into a pressurised protective containment, that might release only gaseous and volatile radioactive substances into the environment).

So, on April 26, 1986, the personnel of Unit 4 of the Chernobyl NPP allowed only one (and short) off-Regulations decrease of only one parameter - operational reactivity margin (ORM). Moreover, before the accident the Institute of Atomic Energy did not consider the parameter to be nuclear-unsafe, as a result, the Chief Designer did not provide for continuous in-built monitoring of the parameter in the reactor design (as the Nuclear Safety Rules would require in the opposite case). However, when the personnel activated the SDS-5 button for a trivial shutdown of the reactor with low ORM, the global-scale accident suddenly happened. In such a way it was not even considered in the design, as a result, the experts categorised it as an absolutely impossible, "super-incredible" accident. Well, if a court assessed the accident as "extremely unlikely", the Designer and the Scientist cannot be blamed for it. Besides that, they saved a lot of money by their opt-out of the reactor protection constructions - the money that proved very useful later for rehabilitation of the Chernobyl NPP. As a result, accounting for their damaged reputation, the reactor developers were not convicted, they were awarded instead. They were awarded for participation in mitigation of the accident they “designed” themselves, the accident that was simply inevitable.

The NPP personnel was treated in a different way. When did the reactor explode? - After activation of SDS-5 button. Who had activated it? - The operational personnel, by their own free will. And the court ruled correspondingly - the accident was caused by people who stayed nearby the “electricity-generating bomb” at the moment of explosion.

Further steps of the Government, trying to “save its face” vis-a-vis the radiation-affected international community, followed the same logic - the NPP top managers were convicted, the other NPP personnel were stigmatised forever. People who were opposed to such an approach were fired, while the dead ones were generously excused, saving then from posthumous blame.

Information note (mine - N.K.):

1. The US experts assessed tangible losses of the USSR as a result of the Chernobyl disaster as $ 170 billion (in 1987 prices). The amount is sufficient to construct more than 150 reactor units at prices of that time. This is the price paid by the country due to “prudence” of scientists and RBMK designers. But how could one assess the losses of the people?
2. After the accident, more than 120 thousand persons were registered as the disabled in connection with impacts of the Chernobyl disaster. More than 80 thousand adults and almost 2 thousand children are listed in the registers of the disabled.
3. By early 2007, registers of public health facilities contained information on 2,381,297 affected persons, including 408,248 persons (Source: the Public Health Ministry of Ukraine. Elena Dub, “Gazeta po Kievski” Newspaper , 24.08.2007 *http://www.cripo.com.ua/?sect_id= 8&aid=40035)*
4. Even without accounting for liquidators of the accident who died in 1986 (the PHM info release does not contain data on them) and without figures for 2005 - 2010, the number of deaths among persons affected by the Chernobyl disaster, reaches almost 430 thousand. If we account for six last years, the figure will reach almost a half million.

МІНІСТЕРСТВО ОХОРОНИ ЗДОРОВ'Я УКРАЇНИ

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4.01-97-1/13/2664

На № 06-15/12-994 від 19.09.05

Комітету з питань екологічної політики,
природокористування та ліквідації
наслідків Чорнобильської катастрофи
Верховної Ради України

На Ваш №06-15/12-994 від 19 вересня 2005 року Міністерство охорони здоров'я України повідомляє про кількість померлих громадян, постраждалих внаслідок аварії на Чорнобильській АЕС, які знаходилися на обслуговуванні у закладах, підпорядкованих системі МОЗ України, за 1987 – 2004 роки. Відомості про постраждалих, які померли у 1986 році, Центром медичної статистики МОЗ України не збирались. Відповідна інформація про померлих у 2005 році, згідно наказу Державного комітету статистики України та МОЗ України №256/184 від 31.07.2000, зареєстрованого в Міністерстві юстиції України 22.09.2000 за №643/4864, буде лише 17 березня 2006 року.

Відомості про кількість померлих осіб, постраждалих внаслідок аварії на Чорнобильській АЕС, які знаходились на обслуговуванні у закладах, підпорядкованих системі МОЗ України:

Роки	Померло постраждалих 1,2,3,4 груп первинного обліку		Роки	Померло потстраждалих 1,2,3,4 груп первинного обліку	
	Від усіх причин	у тому числі від променевої хвороби		Від усіх причин	у тому числі від променевої хвороби
1987	1716	-	1996	37610	2
1988	1801	-	1997	37419	-
1989	2754	-	1998	36102	2
1990	3217	1	1999	36527	1
1991	16065	1	2000	37352	-
1992	32573	-	2001	36986	-
1993	36026	1	2002	37259	3
1994	35919	2	2003	38613	1
1995	37582	3	2004	38524	2

Перший заступник Міністра **С.М.Ханенко**

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20.09.05 # 4.01-978
4.01-97-1/13/2664

in reply to: #06-15/12-994 of 19.09.05

to: the Committee on Environmental Policy, Natural Resource Use and Liquidation of Consequences of the Chernobyl Disaster of the Verkhovna Rada of Ukraine

In response to your request # 06-15/12-994 of September 12, 2005, the Public Health Ministry of Ukraine provides information on numbers of death cases among citizens, who were affected by the Chernobyl disaster, and who were served by subordinate facilities of the PHM of Ukraine, in the period from 1987 to 2004. The Medical Statistics Centre of PHM of Ukraine did not collect information on victims who died in 1986. Relevant information on the number of deaths in 2005 will become available only by March 17, 2006, according to Order # 256/184 of the State Committee of Ukraine for Statistics and PHM of Ukraine of 31.07.2000, registered by the Ministry of Justice of Ukraine on 22.09.2000, reg. # 643/4864.

Initiation on numbers of death cases among citizens, who were affected by the Chernobyl disaster, and who were served by subordinate facilities of the PHM of Ukraine.

Years	Dead victims of 1st, 2nd, 3rd and 4th groups of primary reg. records		Years	Dead victims of 1st, 2nd, 3rd and 4th groups of primary reg. records	
	From all causes	inc. from acute radiation sickness		From all causes	inc. from acute radiation sickness
1987	1716	-	1996	37610	2
1988	1801	-	1997	37419	-
1989	2754	-	1998	36102	2
1990	3217	1	1999	36527	1
1991	16065	1	2000	37352	-
1992	32573	-	2001	36986	-
1993	36026	1	2002	37259	3
1994	35919	2	2003	38613	1
1995	37582	3	2004	38524	2

The First Deputy Minister S.M. Khanenko

The letter to Gorbachev

The letter of G.A. Shasharin to M.S. Gorbachev (draft) [http://accidont.ru/letter.html]

In connection with investigation of causes of the Chernobyl accident I deem it necessary to notify you on a range of facts and considerations.

Now, due to results of analysis of the accident-related materials and research studies conducted by institutes of the Ministry of Medium Machine-building Industry and the Ministry of Power Industry, all specialists generally share a common understanding of the nature of the abnormal process and its underlying causes. A quick runaway of the reactor happened, that caused a thermal explosion with subsequent almost complete destruction of the active core of the reactor.

The causes of the runaway are associated with specific features of physics and design of RBMK type reactors, that were not sufficiently understood earlier. They could manifest themselves to the full extent only under conditions that were created at Unit 4 of the Chernobyl NPP by the moment of the accident. The sequential order of events of the accident and its causes are closely reviewed in the Annex to the Investigation Protocol (the Ministry of Power Industry of the USSR, "Soyuzatomenergo", # 4/611, 16.05. 86) and in MPI Conclusions on results of the research studies conducted in VNIIAES and by other MPI specialists. These materials were submitted to the Governmental Commission and to all relevant organisations.

The fact, that specialists of the MMMI share the same understanding of the accident events and its causes is confirmed by the range of priority measures they proposed at the meeting chaired by Academician A.P. Aleksandrov… The same is confirmed by the Commission's resolution on Volkov's letter. At the same time, I am seriously concerned and I categorically disagree with the position of MMMI in connection with lessons of the Chernobyl accident and associated interpretation of the facts, as well as with the approach to analysis of the accident.

1. MMMI did not provide any materials with results of detailed analysis of the accident events and its causes, while all conclusions rely solely on one document only - the Investigation Protocol (Chernobyl NPP, reg.# 9 pu of 05.05.86), that was drafted on-site, immediately after the accident, when (as it was found later) some details of the events were not interpreted correctly. These details are discussed in the above Annex to the Investigation Protocol, but MMMI ignores it, similarly to the well substantiated conclusion of MPI…

Such an approach to analysis of the Chernobyl accident does not correspond to its scale, gravity of its consequences and the high level of responsibility in charge of decision-making on the investigation results.

2. The works, that were conducted at the reactor according to a specialised program before the accident and actions of the NPP personnel associated with deviation from the operational regulations are considered to be the main - and almost the only - cause of the accident. As these considerations do not include a detailed analysis of every action and every adjustment of the [reactor] operation mode in terms of their impacts on the subsequent abnormal process, they merely reveal a lack of due order in organisation of works at the Chernobyl NPP and a poor technological discipline (we have to agree with that), but they do not bring us closer to identification of real causes of the disaster, moreover, they divert our attention from the main point. The main point of principal importance is associated with the fact that the reactor runaway started after activation of the shutdown system by the operator. In other words, it was a standard operational action of the operating personnel (emergency shutdown) that was the direct triggering event of the accident with disastrous consequences. This means that the design of RBMK type reactors failed to meet the key principle of nuclear safety: under any circumstances, in the case of any wrong actions of operational personnel, the reactor must be protected by its emergency safety systems, nothing to say that a safety system cannot operate against its intended purpose.

3. Design flaws and specific physical features of RBMK type reactors that were the direct cause of the accident seem to manifest themselves earlier as well… In particular, materials of the MMMI Commission in charge of investigation of the accident of 1975 at the Leningrad NPP suggest that one of potential causes under review was associated with strong distortions of the neutron flux related with introduction of positive reactivity by SDS rods, i.e. the same phenomena as in the case of the Chernobyl accident.

However, analysis and lessons of the above accident did not extend outside a narrow agency-specific review. Only some organisational and engineering measures were proposed for safety improvement (the ones that were incorporated into the operational regulations without any explanations). The design of SDS rods was not altered. Operators were not blamed…

In the course of development of second stages of RBMK-based NPPs, the above design flaws of the SDS rods were further aggravated (due to making displacers shorter and increasing their numbers).

The investigation of the accident of 1982 at Unit 1 of the Chernobyl NPP (rupture of technological channel 62-44, with partial release of nuclear fuel into graphite stack - N.K.) was immediately focused on blaming the operators, and even a thought that - similarly to the Leningrad NPP accident - a local neutron flux burst could occur, was immediately authoritatively rejected by the chief designer...

Such an approach to investigation of accidents is absolutely inadmissible in the case of accidents of the Chernobyl scale. The truth must be ascertained to the maximal possible extent, and absolute guarantees of prevention of similar situations in the future must be provided. Such guarantees cannot be provided if we will rely on organisational and engineering measures only.

4. The Chernobyl accident is an unprecedented event that extends beyond the national borders. In the course of formulating the official conclusion on causes of the accident we should presume that technical details of the accident process that caused such heavy consequences will be of high interest to the scientific community and - sooner or later - they will become known to a broad circle of reactor specialists in our country and abroad...

Under such circumstances, the only appropriate option would be the following - to provide objective account of the actual course of events and analytical results, notwithstanding agency-specific or any other non-technical considerations.

5. This letter would not be necessary if a really agency-independent body existed - the one capable of objective analysis of scientific and engineering issues of nuclear power industry, that affect interests of different agencies. The Inter-agency R&D Council (IAC) chaired by A.P. Aleksandrov is not such a body - it was clearly demonstrated by IAC's discussion on results of investigation and analysis of the Chernobyl accident. Instead of specific and professional technical discussion of the materials presented to the IAC, almost the whole session (4 hours without a break) was dedicated to general talking on poor performance of operators and reading out randomly selected documents that allegedly confirmed their faults. Any attempts to criticise design of the reactor and its specific physical features were skilfully terminated by the Chairman or strongly rejected by E.P. Slavskiy. His arguments were based on the following: "earlier, SDS rods were dropped for thousands times at RBMK type reactors, and they did not explode, so they were not set to explode that time"…

They even did not allow a representative of GAEN to present his position on measures to ensure security of RBMK type reactors…

IAC is a body of the Ministry of Medium Machine-building Industry, and IAC decision on the Chernobyl accident reflects the position discussed in this letter.

References to Chapter 2

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Chapter 3. The nuclear industry will never rehabilitate itself after Chernobyl

The mind - set changes

My life and work after the accident forced me to rethink once again whether I had chosen my occupation correctly. The occupation's choice is very important, not less important that the choice of one's spouse. One can hardly expect that many people would willingly opt to get involved into a business that kills the environment, flora and fauna, deteriorate human health... Why, then, did I opt to?

Many years ago, in 1965, when I became a student of the Physics Engineering Department of Tomsk Polytechnic Institute, my future looked bright. Starting from early school years, Soviet propaganda hammered in the pupils with stereotypes that were hardly of any practical value but met aims of the state perfectly. In such a way the authorities promoted and praised nuclear science and engineering that were considered of crucial importance for war and peace times alike. And I swallowed the bait. I always liked physics and mathematics, as a result, I made my choice of future profession quickly and without problems. In the Institute, students were often told about great importance of their specialisation (physical power installations) and we universally wanted to become operating physical engineers as soon a possible.

I started to work as a physicist in Tomsk-7 (now Seversk), at a nuclear plant concealed by abbreviation SCP (the Siberian Chemical Plant). The facility where I started to work impressed me - it was a huge and modern plant. I liked the plant personnel - they were well educated, experienced people, who managed to act calmly and professionally even in serious emergencies, to act with minimal possible risks. Unfortunately, accidents really happened. I had my own share of them as well. I am very grateful to my first superior Vyacheslav Dunayev, who taught me practical skills of individual radiation protection. He shared with me his practical experience of dealing with situations of no choice, when nobody except you could do your work and do it now, because later it would be too late and associated consequences might be huge and severe.

I was somehow upset by the overwhelming secrecy rules that regulated our work and personal life alike. When we made trips outside the city we had to tell the "legend" about the city pre-fabricated by special services to all, even to our parents. But such inconvenience was considered justified as we lived in the midst of the Cold War with "stagnating" West. I was perfectly satisfied by my life and tried to do my best to become a good specialist - it was not easy but it was fairly interesting.

From my early childhood years, I was keen on fishing, backpacking and mountainous tourism, so I spent a lot of time walking in the city surroundings, along local streams and rivers. In one of these rivers, a rather large one with unusually warm water, I saw very strange creatures - almost featherless ducks that were unable to fly and scaleless horn eyed fish. There were many of them and all of them were ill. As I found later, it was shallow Romashka river - the receiving water body of cooling water discharges from "Ivans" (first industrial reactors with direct flow cooling of the active core). I witnessed another even more impressive picture at the other end of Tomsk-7 zone, that was fenced like a state border. It was a huge area of the underground discharge site, where liquid radioactive wastes from radio-chemical production units were pumped to. I saw an ill elk there, the poor animal looked so dreadfully that I will not describe the elk here to avoid traumatising the reader. These two encounters embedded in my mind forever, as a visual image of potential consequences of a nuclear war. For some obscure reason, at that time I did not associate these facts with effects of my current occupation, with inevitable impacts of a major nuclear facility on the environment. At longer distances, environmental consequences became less clearly visible, Romashka joined the Tob River, then the Tob joined the Ob River than delivered the diluted radioactive load into the Arctic Ocean. Only several decades later, when the associated data were declassified, I got information on large-scale health implications of many years of radioactive discharges to Siberian rivers...

For 10 years I faithfully strengthened the nuclear shield of the Soviet Union and finally I realised that life under barbed wire, "under the microscope" of special services started to depress me. I had to think about a new location to live and work.

It was 1979, the period of bloom of the peaceful atom, many new NPPs were constructed in the European part of the USSR and employees of MMMI nuclear plants started to migrate there. I also moved - to the Chernobyl NPP. The location, with its picturesque landscapes, a great river and magnificent forests was a perfect place for a happy life. I predominantly spent my spare time in the nature, touring local forests or fishing. The feeling of belonging to the perfectly clean nature was so great, that I periodically was haunted by a frightening thought - all that might be lost after a major NPP accident. Should a few technological channels of an operational reactor rupture, the environment would change radically. Everything would look as usual, but the visible beauty would conceal a deadly threat to all living things, as it was in Tomsk-7. So, I decided to start preparing for a change of my occupation, but it was too late. On April 26, 1986, Unit 4 of the Chernobyl NPP had exploded.

The explosion of a peaceful Chernobyl reactor contaminated the planet heavier than all tests of atomic and hydrogen bombs, including their military application in Hiroshima and Nagasaki. Naturally, I could not flee from the power plant in such a situation. By my work for mitigation of consequences of the accident I had to atone the guilt of the power industry in the accident, at least partly. By the end of that period I decided to write a book, allowing one to trace the way of the nuclear power industry to the global radiation disaster. The book was written - I called it "Chernobyl. Revenge of the Peaceful Atom". Why "revenge"? Because one cannot treat "atom" as a steam engine. It does not forgive a careless and disrespectful attitude to inmost secrets of the Nature and takes revenge. People use the Nature and its secrets as small and ignorant children, failing to learn lessons. Accidents happened at NPPs in large numbers even before the Chernobyl accident and cases of local radioactive contamination demonstrated their threats to all living things. However, peoples' response to these accidents was insufficient to induce the nuclear power industry to improve its safety. The Chernobyl explosion was necessary to make the World "fed up" with radiation and to start discussing hazards of "peaceful atom". But even the Chernobyl disaster was not enough to force nuclear scientists to design a safe reactor. Why?

How hazardous facilities are designed

The world of science and engineering is a strange one, particularly in terms of safe operation of the technical facilities designed. Let us consider the case of development of nuclear power plants in the USSR as an example. It would seem that by 1986, the industry had already accumulated substantial operational experience and developed emergency-mitigation skills, that could be applied for development of newer and safer NPP units. But hopes of the Chernobyl NPP personnel to get design improvements were futile - the design flaws of RBMK safety and control systems that were identified in the course of operating Unit 1, were not remediated in design of Unit 2, Unit 3 and Unit 4. Specialists of the Chernobyl NPP did not just note these design deficiencies, they documented them as official protocols and submitted to the Chief Designer's organisation accompanied by drafts of our Technical Solutions to remediate them. For several years, the Chernobyl

NPP personnel sought to ensure necessary improvements in the design of the reactor CSS (control and safety system), and even had managed to modernise the system at units 1, 2 and 3 before the accident. The Chief Designer's decision on CSS of Unit 4 reactor failed to arrive at the NPP before the accident. In my first book "Chernobyl. Revenge of the Peaceful Atom", I provided a detailed proof that it was the refusal of the RBMK designers to incorporate SARs (shortened adsorber rods) into the reactor shutdown system that made its SDS to act as a "fuse" of the abnormal process on April 26, 1986. There are numerous examples of such delays in upgrade of already implemented projects, but fortunately not all of them cause so tragic consequences.

However, there is another flaw in the approach to design of complex engineering installations - more dangerous and more common one, that may be observed in major industries of all developed countries worldwide. Here I refer to insufficient application of technical solutions that should prevent grave consequences of even extremely rare accidents at potentially hazardous facilities, be it an NPP, the Large Hadron Collider of an off-shore oil rig. It is absolutely obvious, that "PREVENTING GRAVE CONSEQUENCES" are the key words there - they should be prevented at any combination of possible initial events. Therefore I refer to such possible accidents that are associated with all types of Force Majeure circumstances. Naturally, such an approach entails major finance costs for provision of efficient **containing** safety systems at facilities being designed. Such systems must work even in the case of military attacks against a facility concerned and they must prevent releases of hazardous factors outside protection systems. Should such an approach be applied in the case of the Chernobyl NPP, even after the explosion of the reactor, its nuclear fuel and accumulated radioactive contents could not release to the environment. However, the designers did not categorised the reactor as an explosion-prone installation - as a result, the unit design did not stipulate its placement into a strong pressurised containment of reinforced concrete. But the reactor itself had no idea that, with more than 30 deviations from the Nuclear Safety Rules, it is not explosion-prone and is nuclear-safe, as its designers believed. So, in the night of April 26, 1986, it just exploded "in an unexpected and irresponsible manner". The explosion destroyed its upper metal construction (construction "E", generally called the reactor lid), opening the way for release of deadly radiation to the defenceless environment. All these things happened only because the designers considered the reactor to be safe even without any containing safety systems.

Another example - In the Gulf of Mexico, the off-shore oil rig of Transocean Co. (leased to BP) was set ablaze and exploded. Deepwater Horizon oil rig exploded on April 20, 2010, at the distance of 80 km from

Louisiana coast, and gradually the explosion transformed into an industrial disaster of local and then regional scale, generating severe environmental impacts for the region for many decades ahead. Now, the accident is recognised as one of largest industrial disasters in the human history, compatible to the Chernobyl. These two disasters really have many common features. Shortly before the explosion, a well leak check was conducted at the rig - in the course of the operation, consumption of drilling mud was 3 times higher than usual, but nobody became suspicious and they continued to operate the well. As a result, they got the explosion. 11 persons were killed (9 workers and 2 engineers), seven persons were wounded, 4 of them were in critical condition. Overall, 126 persons worked at the oil rig - a construction of the size of more than 2 soccer fields. Fuel tanks of the rig contained about 2.6 million litres of fuel oil, and after burning for 36 hours, the rig sunk. It happened on April 22, close to the Chernobyl's date. After the explosion and sinking, the oil well was damaged and oil from it started to leak to water of the Gulf of Mexico. The disaster caused discharge of up to 40 thousand barrels of oil per day. The leak was not stopped due to lack of efficient technical solutions. They were not provided for in the design, and they are not available now. The conclusion is confirmed by another fact as well - on June 3, engineers of British Petroleum cut the damaged well pipe in the point of its fracture, as a result, they got just another increase of the oil leak intensity by almost 30%. But should Deepwater Horizon oil rig be equipped by an efficient containing safety system, it would block the sea bottom section of the pipe and prevent the oil leak after explosion of the oil rig.

Such disastrous events are still possible, moreover they become more and more frequent. Why? The answer is simple - the reason is associated with customers, prospective owners of potentially hazardous installations, who seek to have "economically efficient projects". To make this possible, developers underestimate potential accidents, categorise the most grave cases as "MAXIMUM CREDIBLE ACCIDENTS" and then abandon any thought about them, considering them as absolutely impossible. Instead of such grave accidents, that are deemed impossible by developers (and customers), designers stipulate simplified "MAXIMUM DESIGN-BASIS ACCIDENTS", artificially identify their parameters and - at the base of such assumptions - design cheap safety systems with corresponding (i.e. extremely low) efficiency.

If we would follow such logic, we could assume that it is absolutely impossible that our country might be invaded by an enemy in possession of firearms and assume its "maximum design-basis weaponry" to include just clubs and slings. Then, to ensure "efficient protection" from the enemy, we could design and supply wooden tanks to the Army. Who knows, maybe such a situation will be really possible, if armed forces would be privatised, as businesses... The conclusion - if we make a project cheaper at the expense of its safety, we will pay a huge price later for our economic improvidence. Eventually, mitigation costs of industrial disasters are many times higher than savings generated by application of "cheap" projects. It was that very approach of designers in Chernobyl, that ruined the economy of the Soviet Union, while Deepwater Horizon oil rig may make the BP bankrupt unless rescued by governmental structures. By June 14, 2010, the corporation's losses reached $1.6 billion. According to expert estimates, the company's losses might eventually exceed $35 billion.

There are other aspects worth noting, as well. Regardless of ownership rights for a hazardous facility, be it a state (the Chernobyl NPP) or a private company (Deepwater Horizon oil rig), they had a common design deficiency (lack of efficient containing safety systems). But regardless severity of economic losses of owners of exploding facilities, they will always be simply incompatible with losses of the peoples. We pay extremely high for their faults. Some people lose their lives. Others lose their health and native lands that become unsuitable for life. In addition, after accidents, we, not them, mitigate their consequences for a miserable pay, risking our lives and being eventually cut adrift. In addition, people may be disgracefully traduced by deceitful and incompetent authorities as it happened in Chernobyl. Now, in addition to state authorities of Russia, Belarus and Ukraine, that pretend that the Chernobyl-affected people and their problems simply do not exist, such international organisations as IAEA (the International Atomic Energy Agency) and WHO (the World Health Organisation) urge to "close the Chernobyl page".

I am not sure that the approach to design of explosion-prone facilities will be reviewed and changed. Unfortunately enough, in contemporary conditions, attempts of local residents to resist siting such facilities in their locations are usually futile. Their rights in the sphere lack a due legislative support, as a result, authorities often simply cheat them. There were cases when local communities agreed to construction of "conventional" facilities in their locations, but after completion of construction works they turned out to be secret defence facilities. Just one example - in 1966 - 1967, a field kitchen production facility was constructed nearby Cherbourg (France). The regional community approved the construction, but instead of an ordinary field kitchen factory local residents found themselves vis-a-vis ... an environmentally hazardous radiochemical plant for processing of irradiated nuclear fuel (UP2 plant).

***Note:** According to estimates of US analysts, from mid-1980s, the major share of plutonium, necessary for the French military nuclear program was produced by reprocessing spent nuclear fuel of civilian nuclear reactors. Spent fuel was delivered to radio-chemical reprocessing plant UP1 of Marcoule Nuclear Complex for production of weapon grade plutonium for components of nuclear charges, and reactor grade (multi-isotope) plutonium for use as a fuel in breeder rectors. By mid-1960s, growing supplies of irradiated nuclear fuel exceeded processing capacity of UP1 plant. So, in 1966 - 1967, the second radio-chemical reprocessing plant (UP2) was commissioned in La Hague, nearby Cherbourg (Cape Hague, Normandy, France). After that time, these radio-chemical plants started to fulfil another function as well - reprocessing spent nuclear fuel under contracts with other West European countries and Japan.*

I hope, now it is clear why a safe nuclear reactor still does not exist anywhere in the World - because business does not need a safe (and therefore expensive) one. What, then, are IAEA and WHO doing - the agencies entrusted to protect peoples?

What the nuclear science was developed for

Atomic bomb was the first applied product of the nuclear science and industry. Actually, it was the bomb that induced development of nuclear industrial complexes of the US and the USSR - they were developed in a hurry and entailed enormous economic costs. As a result of all these efforts two atomic bombs were dropped on the Japanese without any military need.

"We made the work for the Devil" - by these words, Robert Oppenheimer, the research chief of US military nuclear program, summed up results of the Manhattan Project in 1956. But politicians almost never had such "conscience attacks". The United States continued to produce their atomic bombs and reached the maximum in 1967 (about 32,000 warheads). The USSR produced almost 45,000 warheads by 1986.

Leading global powers (the top ten) spent enormous money to develop their huge stocks of nuclear weapons of dreadful destructive capacity, to create reserves of plutonium and highly enriched uranium. **Starting from the Manhattan Project and up to contemporary times, the US alone invested about $4 trillion into development of nuclear technologies and production of nuclear weapons. Other nuclear countries additionally spent at leas $5 trillion.** Their cumulative expenses ($9 trillion) are compatible with the overall socio-economic development spending of all other 145 countries of the World for 50 recent years.

Current costs of military nuclear programs are also substantial. In Russia, for example, these costs reach about a fifth of all defence spending, and exceed expenditure for environment, science, culture, education and public heath taken together. In addition to the global contamination of the planet by radioactive substances due to nuclear tests, accidents at nuclear facilities and NPP, accidents with nuclear weapons, cost of development of nuclear "sticks" also substantially contributed into adverse impacts on quality of human life and security of the whole planet.

In the USSR, 715 nuclear explosions for test purposes were conducted. The US made 1056 such tests (data for 2001, the last year of nuclear testing). Other countries also contributed: France - 210 bombs, the UK - 45, China - 47, India - 3 and Pakistan - 2. Now, countries do not explode real nuclear devices, but test explosions of subcritical ones still continue.

Nuclear weapons tests resulted in global contamination of the Earth surface by radioactive products and plutonium (a substantial part of plutonium remains intact after explosive nuclear fission). According to Academician B.F. Myasoedov [Communications of the Russian Academy of Sciences, v. 70, # 2, 2000, p. 117 - 128 (Rus.)]: "According to different estimates, past tests of nuclear and thermonuclear weapons released from 5 to 10 tons of plutonium, that distributed evenly at the territories of all countries of the Northern Hemisphere". Is the above amount large or small? If we account for the fact that, before the age of development of nuclear technologies, the whole Earth crust (up to 16 km depth), contained merely about 1 kg of naturally occurring plutonium, even 5 tons is a huge figure.

Plutonium is an extremely hazardous substance with a long half-life (tens of thousands years), and a bio-accumulation capacity. The limit for plutonium air concentration is set at the level of 10^{-9} per 1 m^3 . Plutonium is 10 thousand times more toxic than hydrogen cyanide, the most potent chemical poison. Therefore, there is nothing surprising in the fact that millions people have already died from cancer induced by development, production and testing of nuclear weapons, even not by their military application, and these people had no connection with nuclear programs. These estimates were made by Academician A.D. Sakharov almost 50 years ago, and forced him to abandon works for further sophistication of nuclear weapons. Up to our times, nobody has ever proved him to be wrong, quite the contrary - his estimates are being only confirmed.

Note: *In his paper, published in 1958, in the English version of Soviet "Atomic Energy" magazine, Andrey Dmitrievich Sakharov demonstrated that radioactive releases of explosion of only one bomb of 1 megaton TNT equivalent* *(with a plutonium "fuse") will cause cancer, genetic damage and other health impacts resulting in deaths or heavy adverse health effects for about 10 thousand people. If we multiply the latter figure by the equivalent number of nuclear devices already tested in the World (TNT equivalent of more than 2000 explosions divided by 1 megaton), we will get the real number of people who have died or were severely affected.*

*Taking into account that, for 47 years of nuclear tests, the overall yield of US explosions is estimated to reach 180 megatons TNT, while the USSR adds 285.4 megatons, and all other countries add a few megatons, the cumulative explosive yield of all nuclear tests will reach about 300 megatons TNT. Therefore, the human population loss (10,000 * 300) has already reached approximately 3 million people.*

***Information note** - According to the research results of the European Committee on Radiation Risk (ECRR), all military and civilian nuclear programs that were already implemented by 1989, in the nearest future are expected to cause deaths of additional 65 million people - overall, the figure will exceed the human toll of WW II. The ECRR report demonstrated that previous assessments of risks from nuclear tests and radioactive releases of NPPs were substantially underestimated. In particular, ECRR results contradict to research studies of the International Commission on Radiological Protection (the commission was often criticised earlier for its connections with the nuclear industry).*

Nuclear weapons have actually almost exhausted their capacity as a tool to address military and political problems. Retrospectively they proved to be a useless military asset - all countries with nuclear capacity suffered serious defeats: France and the UK lost their empires, the US and China suffered humiliating defeats in Vietnam, while the USSR lost its war in Afghanistan.

What, then, are all these bombs for? - for "policy games" only. But are not the human costs of these games too high?

Behind the front of civilian NPPs

Having developed military nuclear technologies, the scientific community started to adapt the uranium-plutonium cycle for civilian applications. It was the military nuclear foundation that served as the base for establishment and intensive development of nuclear power industry. In 1974, the International Atomic Energy Agency (IAEA) made a forecast that by the end of 20th century, 4500 nuclear power installations were expected to operate worldwide. But the reality was absolutely different - according to IAEA data, in April 2011, only 442 nuclear units were operational in all countries of the Wold. Summing up - the real figure reached only 10% of the anticipated result.

Why, then, has the IAEA forecast failed to materialise in such a spectacular manner? The phenomenon deserves a detailed analysis, as such impressive mismatches between expectations and reality are not very common in major industries.

Declining shares of nuclear power in the overall electricity generation balance were caused by suspicious attitudes of residents of many countries to the nuclear power, by unfavourable market conditions for nuclear power industry and by moods within the nuclear community itself after the failure to resolve all “nuclear” problems at a tilt. The industry has already accumulated a lot of problems and these problems are associated with serious potential troubles. However, it is good that the time has come when power industry specialists, scientists and politicians (only a few of them, so far) have finally recognised that serious deficiencies do exist in the nuclear sector and sorted out the most important ones:

- existing NPPs are potentially hazardous - none of the contemporary reactor units may be considered secure from serious accidents;
- application of nuclear energy resulted in radioactive contamination of the environment, including large land areas, air and water, as well as materials used in the nuclear power sector;
- nuclear tests, accidents and normal NPPs operations raised the background radiation level on the planet, and - as a result - adversely affected human health;
- practical experience suggests that even now emergency response services are not ready to operate efficiently for protection of NPP personnel and local residents of nearby areas after large-scale accidents, particularly at initial stages.

Let us consider these problems more closely. Officially, a reactor is deemed safe if its radiation impacts do not exceed directive-set values of a few parameters (acceptable releases of radionuclides via ventilation stacks, annual personnel exposure doses, etc.). But actually, all these parameters are secondary, while the primary ones are associated with physical parameters of energy generation in the reactor. It is absolutely obvious, that at higher operational pressure in a reactor, higher fuel loads, and higher temperature of its heat transfer media, operators face more serious difficulties in maintaining these parameters within safe limits, and - correspondingly - the reactor poses higher potential threats. I.V. Kurchatov - the “father” of Soviet nuclear power industry - had reasons to call reactors “smouldering bombs", while Nobel Prize winner physicist P.L. Kapitsa defined NPPs as "electricity generating bombs".

Contemporary pressurised NPP reactors operate at pressures up to 200 atmospheres and at water temperatures over 300 °C. In the course of their operation these reactor generate and contain up to 10 billion Ci or radioactive substances per unit - the figure exceeds the Chernobyl release tenfold. In connection with the latter figure only, all existing nuclear reactors should be recognised as potentially hazardous, as we have all reasons to say that so far the international nuclear industry has failed to develop an absolutely safe nuclear reactor.

The second hazard of nuclear power is associated with accumulation of huge amounts of irradiated nuclear fuel and radioactive waste. Irradiated nuclear fuel (INF) is a lethally hazardous, highly radioactive mixture of uranium and plutonium isotopes, products of fission and decay of transuranium elements, that cannot be stored at the Earth surface. Irradiated nuclear fuel is the highest contributor into the overall radioactivity of the globally accumulated waste stocks. Every year, more than 10 thousand tons of INF are removed from NPP reactors globally. By 2011, all countries had already accumulated more than 300 thousand tons of INF and by 2020 the figure is expected to increase to at least 600 thousand tons. At the same time, there is no generally recognised consensus on safe management of irradiation nuclear fuel, so INF is stored in temporary facilities and gradually deteriorate due to nuclear reactions and decay heat. Nobody has any idea what would happen with fuel assemblies after 50 years of such storage. Maybe this is the reason why lobbyists of the nuclear power industry try to persuade all that INF is not a delayed action radioactive bomb but a "humankind's gold reserve".

One more problem is associated with huge amounts of radioactive waste (RW) accumulated by the nuclear power industry. Now, in Ukraine, we have more than 130 million m^3 of RW, stored in temporary tanks and surface burial sites (instead of durable underground storage in geological formations).

How, then, could it happen that a radioactive "tail" of extremely hazardous substances emerged behind the respectable front side of the nuclear power industry, the tail that endangers all living things on the planet? Did NPP developers really seek to get such an outcome?

When science and industry intend to develop a new super-weapon, they tolerate serious risks associated with its production. It was always so, and it still is, for example in production of nitroglycerine-based explosives. If we look into our history we will see that development and production of new generations of armaments always entailed casualties and required enormous money. Such works usually were conducted in extreme rush, and were always accompanied by major risks (and sometimes by unforeseen new ones).

In the case of civilian purposes, the situation was radically different. In the latter case risks are simply inappropriate - one can be hardly expected to wish buying - say - “an electricity-generating bomb” if safer and cheaper alternative options are available. Moreover, the necessary time for development will not be a critical parameter, even if competition is involved. These considerations suggest that neither private individuals, nor states should opt to take obvious life-threatening risks for a civilian purpose. And now let us compare development of nuclear weapons and development of safe NPPs - the same “safety aside” approach is clearly visible. Both the US and the USSR generously financed development of extremely expensive and useless nuclear and thermonuclear bombs in a very short time, and the both countries have failed to develop safe facilities for civilian application of nuclear fission (and fusion) reactions. Why? Because their governments do not care of their peoples, while the peoples themselves still do not realise problems of nuclear power. How many new Chernobyls and Fukushimas must explode to persuade people? People, it is the time to wake up!

Let us return to NPP waste flows. The system of management of liquid radioactive waste (RW of all radioactivity levels) is prone to serious radiation risks. Highly radioactive wastes are either stored in tanks or pumped underground into deep geological formations (collectors) with unidentifiable nuclear safety. Tanks with radioactive waste need permanent and close supervision, as leaks, damage or thermal explosions may result in major radiation emergencies, like the one that happened in 1957 at “Mayak” Plant (Chelyabinsk, USSR).

RW management is risky, but the number one problem of the global nuclear power industry is associated with storage of spent (irradiated) nuclear fuel. In the late 20th century the latter problem had almost halted further operation of Ukrainian NPPs equipped by WWER-1000 reactors, as the rate of transfer of INF from Ukraine to Krasnoyarsk-26 seriously lagged behind rates of accumulation of new fuel assemblies removed from reactions.

In December 1993, Zaporozhie NPP (whose spent fuel assemblies almost completely filled all fuel cooling ponds at the NPP site) signed a contract with Duke Engineering and Services Inc. for supply of ventilated concrete containers for storage of INF (similar to the ones applied now in the USA). These containers are applied for temporary storage with service life of 50 years. Where should their contents be moved to after expiration of their service life? What will be the state of the fuel 50 years later? How should INF be removed from these metal-concrete containers? These questions still remain unanswered…

The situation with nuclear fuel of the Chernobyl NPP is much worse. Cooling ponds (CPs) of Unit 3 had been already emptied. Unit 1 CP contains 1365 fuel assemblies. Unit 2 CP contains 1354 assemblies. The rest of the INF stock is stored in the overloaded temporary INF wet storage facility (INFS-1), and its service life will expire in 2016. The storage facility lacks a reserve empty section for swift relocation of fuel rods from the main cooling pond if leaked. Now, INFS-1 contains 18565 fuel assemblies, at its design capacity of 17520 assemblies. There are plans to load it soon up to 2,218 assemblies, except damaged fuel assemblies. These additional 3,698 fuel assemblies would add an extra-design load on INFS-1 constructions (410 tons), resulting in a higher probability of depressurising of the INF cooling ponds by earthquakes that occur in the Chernobyl NPP area with frequency of 5 events per 100 years (the last earthquake happened there in 1990).

According to IAEA estimates, by 2011, about 260 thousand tons INF were removed from NPP reactors (442 reactor units worldwide) with radioactivity contents over 150 billion Ci. From the overall INF stock, 180 thousand tons are intended for storage and 80 thousand tons - for reprocessing. One may just wander about the time necessary to reprocess these 80 thousand tons, as in the whole history of the USSR, its nuclear industry had managed to reprocess just about 10 thousand tons of irradiated fuel (data by 2000, according to V. Menshikov, an official of the RF Security Council).

According to minimal estimates, reprocessing of 1 ton of spent nuclear fuel generates:

- 45 tons of high activity liquid waste (after further concentration, fractioning and vitrification the amount decreases to 7.5 tons of solid vitrified radioactive waste),
- 150 tons of liquid medium activity waste,
- 2000 tons of low activity waste.

The average overall activity of the waste flows generated by reprocessing of 1 ton of spent fuel reaches 600,000 Ci.

A question arises - where are these wastes concealed?

The UK and France for a long time have been using loopholes in international treaties and discharge their reprocessing waste to the North Atlantic. Japan follows suit. Russia pumps liquid RW underground or discharges them to surface water bodies. In Ukraine, the problem of disposal of RW and INF remains unresolved. Question - will experience of such competent countries in the sphere of addressing problems related with the nuclear fuel cycle as the US, the UK and France be of any help for us? Answer - no, never. These countries are themselves struggling with the problem of safe disposal of RW and INF without any tangible effect and their expensive “assistance” to Ukraine only aggravates the scale of our future problems.

International Chernobyl projects

Let us recall the contract signed in 2000 with French Framatome Company for "turnkey" construction of INFS-2 for dry storage of INF of the Chernobyl NPP. Having invested ˆ90 million we got useless constructions, unfit for reception of Chernobyl fuel. Now, US Holtec Company asks for an additional amount over ˆ200 million to remediate the storage design flaws that were clearly visible even in 1999 (the ones disclosed by Zerkalo Nedeli Newspaper (## 29 and 48, 1999). Initial plans stipulated that INFS-2 would be commissioned "turnkey" in 2002, then the launch was rescheduled to 2005, and now nobody has any idea when it might happen.

The contract of the National Generating Company "Energoatom" with the US Holtec for supply of containers for storage of INF of WWER reactors to Ukraine, is not less outrageous by no means. The containers were promoted in Ukraine as universal ones, but they are not. They only allow to load fuel and store it <u>temporarily</u> (i.e. they fulfil only some functions of universal containers). Really universal transportation and storage containers allow to store, transport and repackage nuclear fuel. Maybe "Energoatom" has some ideas as to what Ukraine should do 50 years later, when "sordid and temporary" INFS-2 and "temporary" Holtec containers will reach the end of their service life... Lack of necessary equipment and technologies would not allow to remove fuel from them. Without any doubt, by that time some fuel assemblies will depressurise, resulting in possible spillage of fuel pellets. How and where would such fuel be repackaged? Who would address these problems, and what losses would the country bear in this connection?

But Shelter-2 project is surely the most absurd one. Instead of efficient and quick dismounting of the old Sarcophagus, which now is not so dangerous as it was when constructed (by the way, it was constructed within only 6 months!) in 1986, they propose to cover it (in 3 years!) by a new enormous construction of "Arch" type, just to impose additional burden on future generations, that would need to dismantle three radioactive monsters instead of one ("Arch", "Sarcophagus" and the destroyed reactor itself). Otherwise, one can hardly understand the need of constructing a new <u>temporary</u> unpressurised construction over the old <u>temporary</u> unpressurised construction…

Three latter examples reveal only one thing - in 10 recent years, politicians and state authorities of Ukraine, as well as top managers of its nuclear power industry demonstrated their absolute inability to address both the post-accident problems of Chernobyl and current problems of the industry.

Chernobyl is the indicator of quality of the state governance. As failures of all international Chernobyl projects demonstrate, the state governance in our country is inefficient. Moreover, lack of action of the national authorities increases the risk of radioactive contamination of Ukraine and neighbouring European countries alike.

Chapter 4. International Chernobyl projects

Introduction

Chernobyl was recognised by the UN as a global scale problem. According to the UN experts, losses of all countries affected by the Chernobyl disaster reach $1 trillion. The share of Ukraine in the latter figure reaches at least $200 billion. Therefore, the approach to addressing Chernobyl-related problems directly characterises quality of our state governance and ability of country's leaders to deal with global problems at the level of modern science and technologies.

The international community (EU, G7), having adequately assessed the scale of the problem, provide assistance for our efforts and they are ready to continue their assistance in the future, requiring us just to demonstrate high responsibility and efficiency. Unfortunately enough, expectations of donor countries have not been met yet. Former presidents L.D. Kuchma and V.A. Yustchenko followed a consumerist approach to Chernobyl in the sphere of international relations, demonstrating a poor quality of the problem management both in the country and internationally. As a result, no new political initiatives were launched for a long time to extend the scale of international aid and to reduce the burden on the national budget, as well as for delegation of responsibilities to lower - agency-specific - levels of state governance. Due to these factors, inflows of international humanitarian aid in 15 recent years sharply decreased, while efforts to mitigate effects of the industrial accident were scattered. As the problem's status at the national level was lowered, quality of management of Chernobyl-related issues sharply declined, fuelling corruption and resulting in lack of substantial achievements in Chernobyl sphere.

It is universally known, that Ukraine is unable to stabilise or improve its radiation environmental situation without international assistance. However, is it at all possible, in principle, to resolve the following key problems:

- to transfer irradiated nuclear fuel from a temporary storage (INFS-1) to a dry storage for long-term storage (INFS-2);
- to construct a new protective cover over "Shelter" facility;
- to dismount units 1, 2 and 3 of the Chernobyl NPP;
- to rehabilitate contaminated areas for their economic use?

The answer is unequivocal - it is impossible. The Government of Ukraine is unable to mobilise the necessary funding, and cannot provide the necessary personnel (due to radiation exposure dose limitations) for completion of all associated hazardous and difficult works (even the full range of these works has not been defined yet). However, it is possible to improve the situation. For one thing, only one facility should be constructed - only one but the most important facility.

Status of INFS-1 in the range of Chernobyl-related problems

A storage facility for irradiated nuclear fuel (INFS-1) is located at the distance of about 200 m from the Shelter, in the North-western corner of the Chernobyl NPP site. The facility was hastily commissioned in autumn of 1986 with estimated service life of 30 years (up to 2016).

In the course of construction of INFS-1 its design was somehow simplified - the designers excluded construction and installation of a "hot cropping" unit. The unit was necessary for operations associated with transfer of INF to a radio-chemical plant for processing of fuel assemblies and extraction of uranium and plutonium isotopes. Construction of such a reprocessing facility (RT-2) was launched near Krasnoyarsk more than 30 years ago, but is has not been commissioned yet, due to finance problems.

"Wet" storage facility INFS-1 incorporates 5 cooling pools (CPs) for storage of irradiated nuclear fuel (INF), and one of them is a back-up one (for 4320 assemblies). A cooling pool looks like a common swimming pool with the depth of 11 m, with its bottom (approximately) at the ground level, and walls lined by stainless steel plates (1 layer). 7 m high fuel assemblies are stored in special canisters (a pipe with one end closed), that are immersed into water vertically. A water layer over the fuel assemblies is about 3 m thick - the water shield is the only biological protection available to protect personnel from radiation. The CP water supply system prevents decrease of water level in the course of its standard operation mode. However, in the case of intensive leaks from a pool, that may be caused by cracks in the stainless steel coating (as it happened at the Leningrad NPP in 1997, when 21 leaks were found in a CP), or by the self-sustaining chain reaction is a CP compartment, water level might decrease and irradiated fuel assemblies may become exposed. In such a case, exposure dose rates inside the storage facility would exceed 1000 R/hour (10 Sv/hour), making any accident mitigation works in the facility difficult.

Design INFS-1 capacity - 17520 fuel assemblies. Actually, it is planned to be loaded by more than 21000 fuel assemblies, except damaged ones. These extra rods would generate the over-design load of 400 tons.

About 4000 irradiated fuel assemblies that are stored now in CPs of INFS-1 are depressurised. As they were stored under water for too

Photo of INFS-1

long, they are already saturated by water that enters assemblies through casing defects, resulting in expansion and destruction of fuel assemblies. Such water-saturated assemblies cannot be transferred for dry storage to a new INFS. So, a some part of depressurised fuel assemblies (with serious casing defects) will be left in INFS-1, whose service life will expire in 5 years. The situation is further complicated by the fact that the Chernobyl NPP lacks both methodologies and instruments for reliable identification of depressurised fuel assemblies.

INFS-1 poses questions that cannot be answered unequivocally now. For example, nobody knows whether there are bottomless canisters in INFS-1, or fuel assemblies that are so seriously damaged that their fuel pellets fall to canisters' bottoms. Nobody has ever estimated subcriticality of the planned system of a dense storage of fuel assemblies, some of which might be affected by slippage of fuel pellets into canisters. Such redistribution of fuel along the height of INFS necessitates a relevant review of safe storage conditions, as it increases neutron multiplication factor in the INFS pools, etc., etc. ...

Overall, the fuel stock in INFS contains more than 1 billion Ci of radioactive substances. In contrast to radioactive area contamination after the explosion at Unit 4 of the Chernobyl NPP, in the case of an accident at INFS-1, in addition to caesium and strontium, the range of contaminants would also include more long-living radionuclides with half-life periods of thousands years. The INF stock contains more than 4 tons of plutonium isotopes alone. Therefore, contamination after a potential loss-of-water accident at INFS-1 might become unprecedented in the whole history of nuclear power. This means that the spent fuel stock must be transferred to a new dry storage. But the Chernobyl NPP does not have such a storage.

INFS-2 - the "monument" to corruption

In late 1999, under a contract (Contract # C-2/2/033 of July 7, 1999) between the National Nuclear Generating Company "Energoatom" and Framatome Consortium, construction works started at the distance of 2.5 km from the Chernobyl NPP site to construct INFS-2 "turnkey".

The project was financed by an organisation of donors from the "Nuclear Safety Fund". The fund was managed by EBRD (EBRD contributed ˆ68.47 million, while Ukraine contributed UAH 35.94 million).

INFS-2 was designed to utilise a dry storage technology, ensuring pressurised storage conditions and removal of INF-generated heat. INFS-2 was designed to store 25000 irradiated fuel assemblies for 100 years (as it was stated when the contract was concluded). However, the service life of INF-handling equipment of INFS-2 reached only 20 years.

The first stage of the facility was expected to be commissioned in July 2002, while the whole contract's completion was planed to March 2003. But these plans failed to materialise. Why? - Now, we can confidently claim that in 1999 "Enegroatom" had made a fatal mistake and its gravity gradually becomes more and more obvious (in 2000, Ukraine was warned on such an outcome by a UN expert, Dr. G. Falko. Later, I sent letters on these matters to the Verkhovna Rada and Prime Minister V. Yustchenko).

<u>Note</u> *(according to G. Falko [1]) - in order to select the best project option, a tender was organised. Bids to the tender were submitted by three international consortia. "Energatom" actually controlled the tender. All three project proposals, that were presented to Ukraine in 1999, were already well known to Ukrainian and foreign specialists, as relevant storage facilities were constructed and operated at many NPPs in different countries. To the universally shared surprise, "Energoatom" selected the project proposal of the consortium led by French Framatome. To call the proposal the worst of the proposed options will be a serious underestimation. It was the worst possible option. The matter is associated with the fact that NUHOMS technology (the backbone of the project) was developed for fuel of radically different reactors, comparatively to Chernobyl's RBMKs (with different dimensions of fuel assemblies and - what is very important - another U-235 enrichment). The technology is rather complex, and storage facilities are hazardous and expensive to operate. Moreover, the technology is not actually a Framatome's one, it belongs to US Vectra Company, that went bankrupt in late 1997, after a decision of the US Nuclear Regulatory Commission (USNRC) that prohibited production of all NUHOMS systems and components, demanding (for safety improvement) to introduce 2059 (!) improvements into its technology. Its customers, including major US generating companies (Pennsylvania Power & Light Company, Baltimore Gas & Electric Company, Duke Power, etc.) suffered substantial* *losses due to the need to adjust designs urgently. In the case of Robinson NPP, where such a storage facility had been already constructed by that time, the NPP decided that the facility would not be used due to its design deficiencies and high operation costs.*

The NUHOMS technology is practically inapplicable for RBMK type reactors, as it fails to meet the most important requirement - in cannot assure the necessary nuclear safety level (neutron multiplication factor in INFS-2 exceeds the maximal acceptable threshold of 0.95) and does not provide the necessary number of safety barriers (1.5 actually instead of 2 - the minimal number) that prevent radioactive releases from the storage. However, the Ukrainian organisers of the tender did not account for these facts - as a result, the project finally produced an international scandal and failed.

"Energoatom" functionaries were aware of deficiencies of the INF storage technology selected, however, no expert assessment of the INFS-2 contractor's design had been conducted. As a result, they started to construct a facility with so serious deficiencies that the Chernobyl NPP would not be ever able to use it even after introduction of the maximal possible range of design adjustments. At the same time, the tender bids included also two modern technologies that are widely applied worldwide: technologies of SGN-Walter Bau-Ansaldo Consortium (France - Germany - Italy) and EACL (Canada - UK), that were rejected by the tender board.

How did "Energoatom" officials substantiate their choice? They accounted for the difference in bids' costs only [2]. Framatome-led consortium proposed a storage design for ˆ67 million; SGN-led consortium requested ˆ98 million; while ÅÀÑL-led consortium asked for ˆ127 million. At the same time, EBRD allocated only ˆ68 million for the storage. Ukraine was expected to cover costs over the latter figure but the country failed to mobilise funds for selection on an adequate design - as a result the country has lost both time and money.

Accounting for 1 billion Ci of radioactive substances in INFS-1, one can easy imagine consequences of an accident at the facility, especially if irradiated nuclear fuel simply cannot be removed from the storage. Moreover, such a situation did not develop overnight, it was predictable and it was forecasted 12 years ago. Who was made responsible for the situation? Nobody was. Once again, the Chernobyl NPP personnel and the peoples of Ukraine were taken hostages of the situation. The problem might be resolved - albeit partly - after construction of another INFS-2, that has not been launched yet. Should any serious trouble happen meanwhile, we all would suffer... except its real authors, as usual.

The contract with FRAMATOME ANP (France) was cancelled. The money - over $90 million - was wasted but Ukraine got nothing except a few concrete constructions.

The Chernobyl NPP had to look for another contractor and found Holtec International (US). On 17.09.2007, the Chernobyl NPP and Holtec International signed Contract # ChNPP-Ñ-2/10/062 for "Completion of the Dry Irradiated Nuclear Fuel Storage at the Chernobyl NPP Site". Costs of construction works are estimated to reach more than $200 million. The story gets another turn - we have a contract but we do not have INFS-2, while nobody knows when we will get one and what a sort of facility will it be. A new scandal seems fairly likely.

ARCH project or "Shelter-2"

How the project started

The majority of specialists long ago realised that the real threat of the "Shelter" is not of nuclear nature, it poses a radiation threat. The threat is associated with many tons of radioactive dust (including fuel matrix), that might release to the NPP site should the "Shelter" constructions collapse. To prevent such a course of events, in December 1991, two decrees were passed by the Verkhovna Rada of Ukraine and the Government on a contest for the best engineering solution for "Sarcophagus-2".

In 1993, the EC Commission launched a tender for a feasibility study to transform the "Shelter" facility into a "green field" site. The contract was awarded to Alliance (an association of European companies).

In July 1995, the feasibility study was completed. The developers made the following conclusions:

- the existing "Shelter" facility was constructed without a due accounting for seismic impacts;
- the facility's construction design does not provide for its long-term operation;
- it is necessary to construct a new protective cover;
- design and construction of the new protective cover is a complex, multifaceted task - therefore Ukraine will not be able to finance implementation of such a project independently.

In 1997, American and European specialists developed the **Action Plan,** defining the necessary actions and works for upgrading the "Shelter" into a safe facility - the Shelter Implementation Plan (SIP). The key objective of the Plan is associated with construction of a new protective cover that would guarantee the facility's safety for 100 years, and development of a strategy for removal of fuel-containing and radioactive materials. In order to provide finance support for SIP implementation, the International Chernobyl Fund (Shelter Fund) was established. Its participants (28 countries) agreed to donate $760 million to finance the works planned. Ukraine's contribution reached $50 million.

In 1998, 20 countries and the European Union, that decided to become donors of the Chernobyl Fund, associated into the Donors' Assembly.

On February 4, 1998, the Verkhovna Rada of Ukraine ratified the Framework Agreement between Ukraine and EBRD on Activities of "Shelter" Chernobyl Fund.

It is necessary to note, that construction of the new "Shelter" is not a charitable venture of the European Bank for Reconstruction and Development. It is a joint project of G7, the European Union and Ukraine. Actually, construction of the "Shelter" is an investment project with Ukraine as one of the investors (albeit not a major one). So, our taxpayers should be interested to know what their money is used for and how efficiently.

In 2001 - 2003, as contracted by the Chernobyl NPP, the US-France consortium developed a **conceptual design** of a new safe containment for the destroyed reactor unit. The containment is understood as an enormous **non-pressurised** “Shelter-2” - a metal hangar assembled of arch-shaped construction elements (height - 108 m, length - 150 m, span - 257 m), that would protect the old Shelter from winds and precipitation only.

The design documentation on the confinement was submitted to Ukraine in December 2003 for a comprehensive state expert assessment. Without waiting for outcomes of the expert assessment, on March 11, 2004, the Chernobyl NPP announced a tender for design, construction and commissioning of the new safe containment. Top managers of the NPP had provided no substantiation for their hurried and illegitimate actions.

In March - April of 2004, the Ministry of Fuel and Energy of Ukraine had suddenly “awakened” and initiated a public discussion on the conceptual design of the new “Shelter” - the step that should have been made at the very beginning of the design development instead of afterwards its completion. Two “round tables” were held, as well as a session of the National Commission for Radiation Protection of Ukraine’s Population and the National Acad. Sci., joint sessions of the Nuclear Power Section of the R&D Council of the Ministry of Fuel and Energy of Ukraine with the Academy of Construction of Ukraine and the Academy of Engineering Sciences of Ukraine. Public hearings on the project, with participation of residents of Ivankovskiy and Polesskiy districts of Kievskaya oblast were conducted in Slavutich - a place of residence of the Chernobyl NPP personnel. The conceptual design of “Arch” shelter failed to get “universally shared” support. Some people assessed it positively, while some other were against the proposal. Some participants even stated that implementation of the proposed conceptual design contradicts to national interests of Ukraine.

So, is it appropriate to install such a super-expensive and super-useless construction at the NPP site?

Academician E.V. Sobotovich (the National Acad. Sci. of Ukraine) expressed his opinion on the new Shelter project in the following words: “They want to install a new 105 m high construction above the already existing cover of Unit 4 - the Sarcophagus. In terms of volume, it amounts to 2.5 million m^3. Nothing like that has been ever constructed in the whole history of mankind. Construction specialists wander how to do it, for example, how should one deliver the construction assemblies to the site - some of them are up to 200 m in length. Another question - how should one transport the construction to the Sarcophagus and cover it? The construction is not assembled over the Sarcophagus - it is risky - it is assembled nearby! Then they want to pull the Arch by rails and cover the “Shelter” … They provided for a sequence - we assemble the Arch, cover everything and that is all. But they are silent about processes inside. Should the “Shelter” collapse, the “Arch” would surely protect us. But nobody would ever be able to come inside. To avoid that we need to reinforce the “Shelter”- but if we do, what then do we need the “Arch” for?

We advised them to install some exhaust ventilation there with dust filters, to do some other things... But as the final outcome, the design developers merely introduced some cosmetic improvements and raised the costs from $280 million to $600 million, and now up to $1.3 billion”.

Comments on the project

Trying to make the project as simple and cheap as possible, its developers (under pretext of insurmountable difficulties associated with removal of radioactive materials from the destroyed Unit and lack of modern storage facilities for radioactive waste in Ukraine) have proposed - as the only feasible option - the concept of a long-term (up to 300 years) storage of radioactive materials inside the “Shelter” facility. The removal of radioactive materials in the lifespan of one generation is not considered as the highest priority any more, in contrast to guidelines of the Ukrainian Government of 1996. According to Article 6 of Law of Ukraine on General Provisions of Further Operation and Decommissioning of the Chernobyl NPP and Transformation of the Destroyed Reactor Unit into an Environmentally Safe System, removal of fuel-containing materials is now considered merely as “one of priority measures for transformation of the “Shelter” facility into an environmentally safe system.” Is it a positive development or a negative one?

Planned service life of the containment (up to 300 years) would require involvement of at least 15 generations of our peoples (300 years : 20 years = 15 generations). The figure makes us logically conclude that implementation of the conceptual design in its proposed form contradicts to long-term interests of Ukraine... unless we intend to conduct a long-term experiment with over-exposure of a particular nation.

Another aspect of principal importance - safety of the Chernobyl NPP personnel and the whole population of Ukraine may be guaranteed only by a reliable isolation of nuclear fuel and radioactive materials from the environment. An unpressurised confinement, constructed as a metal hangar with non-durable two layers of exterior coating, cannot meet these requirements. Construction of a new protection cover would merely produce an illusion of transformation of the “Shelter” facility into an environmentally safe system. The radioactive materials inside would continue to pose a real threat, while releases of fine

Projects' costs rise			
Projects 'costs and contractors of international projects at the Chernobyl NPP			
Projects	Contractors	Initial cost estimates	Adjusted costs estimates
INFS-2	Framatome Campenon Bernard-SGE and Bouygues Travaux Publics (France)	€52.4 million + $18.5 million	€95.7 million
The plant for processing liquid radioactive waste	BELGATOM / SGN / Ansaldo Nudeare (Belgium / France / US)	€17.4 million	€33 million
The industrial complex for processing solid waste	RWE NUKEM Gmbh (Germany)	€33.3 million	€47.7 million
Stabilisation works at "Shelter" facility	"Stabilisation" Consortium: "Atomstroyeksp-ort" (Russia), "Yuzhteploener-gomontazh" Co., Rovno NPP Construction Directorate, "Atomenergostr-oyproekt"(Ukrai-ne)	$46 million	$46 million
The new safe containment	The contractor is not defined	$500 million	$1,200 million
Source: the Ministry of Emergency Response and Protection of the Population from Consequences of the Chernobyl Disaster			

particles (containing the fuel matrix) from the new cover are simply inevitable.

However, even such arguments did not induce the project developers to consider other options to address the problem - the obvious ones that were suggested by the layout of interconnected buildings of 2nd NPP stage - the "Shelter" facility, "B" unit (the highest building with the ventilation exhaust stack) and Unit 3 building (decommissioned in 2000). All these buildings are component parts of single construction complex - the layout allows to move from one part to another using both already built passages and the ones that might be purposefully constructed inside the NPP building. At the stage of the project feasibility study, an option was considered to use the whole technological NPP space (including the adjacent "B" unit and Unit 3) for removal of radioactive materials from the "Shelter" facility. However, the option was considered as a purely theoretical one as it contradicted to main SIP principles (according to the principles, transformation of the "Shelter" into a safe system would not obstruct continuation of the NPP operations). However, the NPP was decommissioned in 2000, and now there are legitimate grounds to adjust the project. The possibility to arrange a transportation passway to the "Shelter" facility from adjacent Unit 3 (in order to use later its operable technological infrastructure for transportation of radioactive materials from "Shelter") eliminates the need to construct the containment and makes the whole project one order of magnitude cheaper. However, some Western "well-wishers", with participation of Ukrainian authorities and academics, unilaterally reviewed the SIP contents. First of all, they actually abandoned the idea or removal of the radioactive substances and focused on construction of the confinement only. In this situation, interested parties clearly understand their benefits - construction of a long-term storage confinement entails associated long-term maintenance contracts to maintain it in a due operational order. Estimates suggest that minimal annual costs of the confinement might reach at least $15 million (the maximal estimate suggests up to $50 million). In 300 years, these costs would reach from $4.5 billion to $15 billion. The latter figures do not account for potential claims of many new "liquidators", who may suffer effects on internal plutonium exposure in the course of their confinement maintenance works. Nevertheless, contemporary Ukrainian authorities still do not bother why the requirements of the Ukrainian law to functions of the new confinement are not met (see Law of Ukraine of April 26, 2001, on Introduction of Amendments into Some Laws of Ukraine in Connection with Decommissioning of the Chernobyl NPP - Article 1 of the Law specifies the future fate of "Shelter-2" by the following amendment: "Confinement is a protective construction, incorporating a set of technological equipment, necessary for removal of materials containing nuclear fuel from the destroyed Unit 4 of the Chernobyl NPP, for management of radioactive waste, and other systems for implementation of measures to transform the Unit into an environmentally safe system and to ensure safety of the NPP personnel, the general population and the environment”).

Let us return to the finance problem. In the period of 12 years, after ratification of the agreement between the Government of Ukraine and the European Bank for Reconstruction and Development by the Verkhovna Rada of Ukraine (the agreement on terms and conditions of operations of the Chernobyl “Shelter” Fund in Ukraine), the following steps were made:

- From the overall amount of the funds disbursed, the major share of finance resources (more than $250 million) were paid for production of feasibility studies, concepts and programs, as well as for services of Western specialists and experts. It is worth to note that the budget provision for support of the Project Management Team for 10 years (from 1997 to 2008) was set at the level of $49.4 million, but by early 2004, the actual expenses had already reached $81.4 million. At the same time, some important objectives of SIP, such as management of water and fuel-containing materials, the emergency dust suppression system (with the overall budget provision of $282.4 million), were actually funded at the level of 5% to 30%. By early 2004, the overall costs of the already implemented works under SIP reached $187.6 million (or about 25% of the planned amount). If we account for overhead costs of the Project Management Team, costs of real (physical) works will become even lower - $106.2 million or 15%. All these data were provided in the memo on audit of the transformation works at the “Shelter” facility conducted by the Accounts Chamber of Ukraine in 2004. Unfortunately, these data were accessible only to a narrow circle of specialists and did not become public.

Maybe, it is not worth to blame only the Ministry of Fuel and Energy, the Ministry of Emergency Response, the Chernobyl NPP and foreign partners for these abuses. It is necessary to recognise that the national authorities of Ukraine are responsible for everything that happens in the country and - correspondingly - for developments in Chernobyl. This is the key reason why more than $250 million were wasted for no practical effect whatsoever. One ought to expect something like that in a country where laws are not enforced - as a result, nobody may be held responsible for crimes.

Well, what should be done, is it possible to improve the situation? Yes, it is possible. According to our legislation, the confinement’s construction may be launched only after issuance of a relevant license by regulatory and supervisory authorities. If these authorities manage to approve a design option that really meets national interests of Ukraine, the country’s reputation may be restored.

Information note *(mine - N.K.)*

The information note was drafted at the base of analysis of the Conceptual Design of the New Safe Confinement. (The Chernobyl NPP, 2003, in 3 volumes).

1. A new protective construction - confinement - is designed as an "arch-type" cover. The cover is to be assembled nearby Unit 4 and then moved to cover it. The new "sarcophagus" should have service life of al least 100 years. Construction of the foundation of the new sarcophagus is to be launched immediately after completion of works to stabilise constructions of the already operational "Shelter" facility. The confinement may become an unprecedented construction project in history. First, its scale is impressive - its foundation only is estimated to consume (according to rough estimates) 100 thousand m^3 of soil, 30 thousand m^3 of supporting plates and 70 thousand m^3 of concrete. In addition, the arch itself should bear about 18 thousand tons of special construction steel. It will be necessary to manufacture arch-like segments (L 65 m, H 12 m, W 12 m). These segments will be assembled to construct 4 sections that will be moved to cover the contemporary "Shelter". It will be necessary to provide for special transportation arrangements just to deliver these arch segments. By the way, the project developers have not proved stability of the construction with its enormous weight on water-impregnated sand soil of the Chernobyl NPP site.

2. The feasibility study of the "Shelter" confinement was developed by an international consortium including Bechtel (US), EDF (France) è Battelle (US) with participation of "Energoproekt" Co. (Kiev R&D Institute), the State R&D Institute of Boiling Constructions and "Shelter" Inter-disciplinary R&D Centre of the National Acad. Sci. SIP does not provide for establishment of a storage facility for fuel-containing materials and removal of solidified melts from the "Shelter" - a new separate project would be necessary for the latter purposes.

3. Such constructions are absolutely inadequate in terms of radiation safety. A metal construction of the "Arch" covered by thin layers of plastic and aluminium is unstable to temperature effects and cannot ensure radiation protection. In addition, the conceptual design is absolutely silent about annual radiation exposure loads on the "Arch" maintenance personnel.

4. Developers of the conceptual design have failed to provide a convincing proof of the need to construct "Shelter-2". The Government of Ukraine declared removal of fuel-containing materials and other radioactive waste as the main objective of transformation of "Shelter" facility, but the conceptual design fails to substantiate the need to construct the second protective cover.

In nuclear terms, "Shelter", with its 30 tons of residual nuclear fuel after the explosion (the actually discovered and documented uranium stock there), is not the most hazardous facility of the Chernobyl zone. Theoretical possibility of a chain fission reaction remains only in the southern INF cooling pond of Unit 4 (by the moment of the accident, about 140 fuel assemblies were densely stored there). Other fuel assemblies or their fragments are located irregularly within the Unit space and elsewhere, making emergence of a critical system in "Shelter" impossible. The latter assumption was confirmed by 25 years of operation of the facility after the accident. In order to arrange a critical system of irradiated fuel assemblies within the facility, it is necessary to have at least thirty densely packed fuel assemblies with a neutron moderator between them - but there are no such formations in "Shelter". Unit 4 reactor also does not pose any hazard, as its active core is empty. It is really so empty that some people even explore the space periodically. Konstantin Pavlovich Checherov, a well known explorer of "Sarcophagus", told me about that: "For the first time, a video footage of the empty active core was made in autumn 1988 by a group of NIKIET specialists led by N. Zhukov, via wells bored from compartments 427/2, 605/2 and 207/5 (from beneath with some inclination). Later, a photo camera was inserted through the well pipe and rotated to photo the empty shaft of the reactor. The trick was designed and implemented by Ibragimov G.D., Berestov A.L. and Pryanichnikov V.A. In December 1988, I.Yu. Mikhailov and me (Checherov K.P.) penetrated into the under-reactor compartment through the northern slide gate. In 1989, we managed to worm thought into the reactor shaft itself. Video-recording was made by G.D. Ibragimov - he used UMATIC shoulder camera, but it was fixed on his back and he could not push through with it - so he had to shoot through the opening. In 1995, we entered the reactor shaft once again, it did not contain fuel initially and no new fuel appeared there".

Construction of a new "Shelter" over Unit 4 that practically contains no nuclear fuel is a useless waste of time, human lives and taxpayers' money. The old "Shelter" poses purely radiation-related risks, not nuclear ones and these risks should be addressed without delay. Why? Because:

1. In contact with air uranium fuel matrix destroys in 20 year. This means that fuel pellets from damaged fuel assemblies in "Shelter" already transformed into dust. With time, due to internal release of energy due to decay processes, the dust will become finer, reaching so small particle sizes that make natural lung protection mechanisms useless against penetration of hazardous transuranium elements. **Such nano-particle aerosols may remain airborne for a long time and cover thousands kilometres with winds.** Therefore, dismantling of "Shelter" and removal of fuel-containing materials should be initiated immediately. Relevant technologies are already developed and in economic terms the option is one order of magnitude cheaper than construction of the new "Shelter".

2. The "Shelter" facility itself practically contains no uranium, the figure of 200 tons of uranium is merely a myth for the naive ones.

Is it necessary to dismantle the old Sarcophagus?

The explanatory note to Law of Ukraine on the National Program on Decommissioning of the Chernobyl NPP and Transformation of the “Shelter” Facility into an Environmentally Safe System suggests that “it is practically impossible to separate works for decommissioning of the Chernobyl NPP and transformation of the “Shelter” facility into an environmentally safe system” and specialists of the Energy Ministry of Ukraine had developed the National Program to ensure inseparability of the associated works and optimise them. Nobody objects to the aim of the Program, reflected in its title. However, its text generates a lot of questions.

Question 1 - could one consider the following two processes as inseparable - the first one (decommissioning of the Chernobyl NPP) will be completed in 2012, when the last fuel assembly from the NPP will be transferred to the INF storage, while the second process (transformation of “Shelter-2” into an environmentally safe system) is expected to be launched in some indefinite time (the Program suggests “approximately in 30 to 50 years”), and nobody knows when it might be completed (the Program provides for about 100 years)?

Lithuania with its RBMK-1500 units selected another option. On demands of the European Union, Unit 1 of the Ignalina NPP was shut down on December 31, 2004. No, a new INFS is being constructed at the NPP site. The storage facility was commissioned in 2008, and they started to remove the fuel intensively. The process will take about 5 years and then, in 2013, the NPP personnel will start to dismantle the reactor. Powerhouse equipment is being already disassembled. In their case, they have 9 years of the time span between the reactor shut down and its dismounting. The time span is fairly sufficient and reasonable, in both finance and physical terms. Due to these reasons, the Lithuanian Government opted to rely on the immediate dismounting strategy. This means that in 30 years, nothing will remain at the Ignalina NPP site. Besides that, they selected the option to retain personnel capable to make the necessary works professionally. They started to shut down Unit 23 of the Ignalina NPP on December 31, 2009, at 20:00 local tine (21:00 Moscow time).The reactor had been shut down on December 31, 2009 at 23:00 local time (00:00 of January 1 Moscow time). Therefore, Lithuania had fully fulfilled its commitments to the European Union.

One more example - in Russia, at a mining and chemical plant nearby Krasnoyarsk, in 1992, ADE-1 type reactor (RBMK prototype reactor) was shut down. Now, 15 years after its shutdown, the reactor had been completely dismounted.

In Germany, at Greifswald NPP, 5 reactor units with WWER-440 reactors were shut down in 1990. 15 years later, all these reactors were dismounted, irradiated fuel and radioactive waste were transferred to dry temporary storages. Moreover, personnel radiation exposure doses in the period of dismounting were much lower than in the course of the NPP operations. The above examples (and other examples as well) of immediate dismounting of reactor units after their decommissioning prove that delayed decisions are factitious and lack serious physical substantiation. Delayed dismounting may result only in excessive costs for useless maintenance of idle reactor units and loss of personnel's skills.

Question 2 - how much would Ukraine pay for implementation of the Program? No answers. On January 30, 2007, the Minister of Emergency Response suggested the figure of $1 billion to UNIAN - the amount covered only costs of completion of facilities for processing liquid and solid radioactive wastes, and construction of a dry storage for INF and a new Shelter. At the same time, costs of the works necessary to transform the Shelter into an environmentally safe system, still remain unknown. The costs of waiting for the launch of the Program-stipulated works would reach at least $3 billion, accounting for annual budgetary allocations of $50 million for maintenance of the Chernobyl NPP ($50 million x 50 years = $2,500 million plus costs of infrastructure development works).

Besides that, the construction of "Shelter-2" does not mean creation of an environmentally safe system - the declared objective the National Program. The Chernobyl zone might become environmentally safe only after final burial of all radioactive materials and dismounting of the reactor units, however, the Program does not provide for costs of relevant works.

Question 3 - who will be held responsible for the Program implementation failure and how? The latter question may be answered right now - nobody will and by no means, as 100 years later, only memories will remain on the contemporary managers of the Program. These memories are likely to be fairly negative if the Program-related developments would follow the usual scenario of recent years, with large-scale abuses and international scandals, with the guilty parties remaining immune to Law. Moreover, some top managers of the Chernobyl zone were even awarded, maybe for the failure to build facilities for processing of liquid and solid waste at the NPP site (the planned deadline for completion of these EU-funded facilities have been already exceeded by 5 years). The dry INF storage - INFS-2 - proved to be unfit for operation, exactly as experts warned so early as in 2000. The selected design option of "Shelter-2" will follow the same fate -

it will become just another monument to international corruption and unprofessionalism, deeply entrenched at the Chernobyl NPP.

Everything of some material value is being taken from 30 km exclusion zone, even iron water heating radiators from Pripyat, jeeps with hunters ride in close proximity to the NPP site admitted by the zone administration. Safety was taken hostage by greed. So, nobody was surprised when fragments of fresh nuclear fuel were stolen in 1995 from the NPP site itself, and nobody can guarantee that some criminals have not taken high activity radioactive materials for a "dirty" nuclear bomb from the Chernobyl zone, fenced only by 30%. In technical terms it is fairly easy - let us just remind that in 1986, a fuel assembly ejected by the explosion from Unit 4, was delivered by truck to Kurchatov Institute.

Could one consider seriously a document that provides for nothing specific - no deadlines, no full cost estimates, no clearly defined responsibility for implementation of the Program or a failure to? I do no think so. It is not a program, it is merely a wish list, that cannot address Chernobyl-related problems, just the opposite - it would aggravate them substantially. The conclusion naturally emerges from an objective assessment of inappropriately low quality of management of Chernobyl problems at the national level, from analysis of outcomes of the works in 30 km exclusion zone in recent years.

So, what do we need another temporary "Sarcophagus" over the old one for? What is the threat posed by the old "Sarcophagus" (the official name of the construction in 1986)? High officials of the Ministry of Emergency Response argue that the threat is associated with unknown bearing capacity of support constructions under its "roof" and many tons of radioactive dust (including destroyed fuel matrix) that would release if the "Sarcophagus" top constructions collapse. They propose to cover "Sarcophagus" by a new enormous (temporary) construction and wait for collapse of the old one, accompanied by release of radioactive dust inside. What, then, would be the next step? According to their logic, "Sarcophagus-2" should be covered by "Sarcophagus-3" - as a result, Ukraine is expected to get a gloomy and very expensive "Chernobyl nested doll" and become the global leader in the stupidest construction projects. Why, then, cannot we remove fuel-containing particles now, as amounts of radioactive dust increase every consecutive year, while particle sizes become more and more smaller? Continuous nuclear decay reactions in the fuel matrix make particles so small, that in about 10 years, they cannot be retained by the new "Sarcophagus" and even by all contemporary known filters (according to forecasts of Ukrainian scientists who study conditions of fuel-containing materials). So, is it necessary to launch construction of such a super-expensive and super-useless construction? Just to play a dirty trick for future generations? Or to make more money from the mess? So far, no bricks were laid into the construction's foundation, but almost $400 million already disappeared from the fund. Do not these facts suggest that the national level has lost control over management of Chernobyl-related works?

Dangerous initiatives of the authorities in Chernobyl

Notwithstanding associated radiation hazards, 30 km exclusion zone in Chernobyl attracts curious and enterprising people. After the accident, it was impossible to seal the exclusion zone completely, as a result only 30% of its perimeter were fenced. With time, a lot of "holes" emerged even in the partial fence - the holes were used by all people who did not want to contact Militia patrols in the zone. Residents of nearby villages entered the zone for haying or hunting. They trapped horses in the zone and used them for agricultural work.

Later on, scrap metal hunters started to visit the zone and new temptations emerged. In the course of the accident mitigation works, a lot of machinery and vehicles were used, with time they became so heavily contaminated by radionuclides that their deactivation became impossible. The equipment was declared unusable and booked off. Nearby Buryakovka and Rossokha villages, two "bone yards" were arranged. These sites are still filled by concrete carrier trucks, military APCs, crane trucks, military helicopters, trucks, tractors, bulldozers, scrapers, excavators, etc. For many years, both the zone personnel and outside "stalkers" disassemble and cannibalise them. Then, machine parts and assemblies are sold at flea markets of Kiev and other cities. One may just wander about the fate of helicopter engines disappeared - they were prohibitively heavy for "stalkers".

Why such dangerous looting continues? The monetary value of all these radioactively contaminated material items was set as zero. Correspondingly, nobody can be criminally prosecuted for stealing equipment and materials that cost nothing.

Under pretext of inability to stop unauthorised entry of people to the zone, the Ministry of Emergency Response decided to open the zone for organised tourism. In such a way, "Chernobyl Interinform" tourist company emerged shortly before 10th anniversary of the disaster. Having paid a good price in dollars and grivnyas, one can visit the abandoned city of Pripyat in protective coveralls and take a guided excursion trip to "Sarcophagus". Now, the zone Administration is making a new step - they intend to open a memorial park in Chernobyl (at a wasteland and abandoned buildings) by 25th anniversaruy of the NPP explosion. The associated works were already launched, the first stage of the park will cover the area of 5 hectares. According to estimates of the exclusion zone specialists, the memorial park might attract additional tourists to Chernobyl. In 2009, the zone was visited by 7 thousand tourists, while in 2010 the figure increased to 10 thousand. According to the Ministry of Emergency Response of Ukraine, the Chernobyl zone is ready to accept even higher numbers of tourists, including foreign ones. Is it safe for tourists to visit the zone now, including healthy and weakened, young and older ones?

Now, Chernobyl hazards are radically different comparatively to 1986 - 1996. Let us ignore the external exposure and focus on internal one. Now, radioactive dust of sub-micrometre sizes is not contained inside the "Shelter" facility. The dust cloud, being permanently fed from the "Shelter", covers the whole NPP site, Pripyat and the central area of the exclusion zone. The dust cloud is fed from two sources - by "gentle" releases with winds and "rough" releases due to activation of dust suppression installations. These installations are poorly efficient by design as the number of their water injection nozzles is substantially lower than the number of dust sources. Periodically winds blow the dust far away, even outside Ukraine. Entering the dust cloud is like immersion into water - nobody will remain dry and will inevitably take some part of the dust that will burn a human body for the rest of one's life. As dust particles are of sub-micrometre range, no respiratory tract villi are capable to remove it, no periods of half-release are applicable. Individual protective gear is also useless in such a case. Summing up - any person who enters the zone will take a portion of the dust.

A few words about potential destruction at the tourism routes associated with seismic activity in the area. An earthquake would predominantly demolish even not the "Shelter" itself but abandoned buildings in Pripyat - the key attraction of Chernobyl tourism. So, in the case of permanent presence of tourists in the zone, they will inevitably face disastrous situations. Someone will have to be held responsible. **Earthquakes cannot be predicted or terminated**. Nevertheless, a flow of tourists is expected there soon. Being photographed at the background of the "Shelter" they would not even suspect, that a plain grey concrete construction nearby called INFS-1 contains 1 billion Ci of radioactive substances. They would not expect that at any moment, after a sudden earthquake, tottering building of Pripyat may fall onto their heads, that water with millions Ci may run out from INFS-1 under their feet.

Information note on earthquakes in the Chernobyl zone

From "The 'Shelter' Facility. History, Status and Prospects" (pp. 156 - 158)

In the area of the Chernobyl NPP site, a network of tectonically active fractures exists (South-Pripyat and Teterev fractures). Therefore, intensive earthquakes within 30 km exclusion zone represent a real threat that might damage constructions of the “Shelter” facility.

It is necessary to note that the groundwater level in the area of the “Shelter” facility raised in 1992 to 110 m (1.5 m from the facility’s foundation). As a result, seismic stability of the “Shelter” facility is compromised.

Table
The history of intensive earthquakes

Date (year)	Magnitude in the epicentre	Magnitude in Kiev
1790	8–9	4–5
1802	9	5–6
1821	8	5
1829	8	5
1838	8	4-5
1908	8	5
1940	8	4–5
1940	9	5
1977	9	5
1990	8	4–5

PART II. FUKUSHIMA

Chapter 5. Fukushima, Chernobyl's Sister

"Japan was hit by a disaster" - that was the message that started my day of March 11, 2011. At 14:46 local time, the country was hit by a powerful 9-magnitude earthquake. North-eastern areas of the country were swept by the earthquake-induced tsunami.

The earthquake cut off power supply in millions of houses. In the capital city and its suburbs, fires erupted on at least 14 major industrial facilities, including oil refineries and storage facilities. Eyewitnesses reported that telephone communications in Tokyo were off, but Internet was still accessible.

Narita and Haneda airports in Tokyo terminated their operations, metro and commuter trains in the city stopped. Airport and land transport closures, fires and destruction were reported by other Japanese cities as well, including Yokogama and Nagoya. Tsunami alerts were sent to inbound ships.

According to a statement of the Nuclear and Industrial Security Agency, at four nuclear power plants in earthquake-stricken Tohoku district, safety systems shut reactors down automatically. No cases of abnormal radiation levels were registered. Overall, 11 reactors were located in the risk zone, including 6 reactors of Fukushima NPP, 3 reactors of Onagawa NPP and two reactors of Tokai NPP. All other NPPs were relatively safe. At the largest NPP - Kasiwazaki-Kariwa of Japan's Tokyo Electric Power Co. - 4 of 7 reactor units were in operation while three other units were shut down and safely cooled.

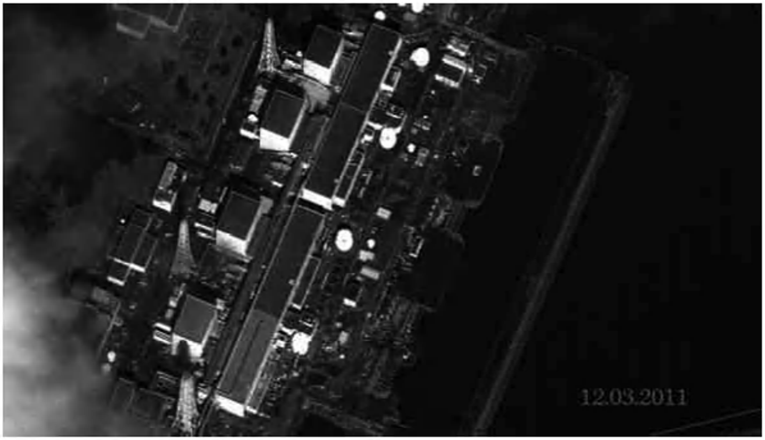
Overall, there are 54 reactor units in Japan. NPPs generated about a third of the country's electric power. The share was expected to increase up to 41% by 2014. The largest NPPs include Kasiwazaki-Kariwa (5.5 billion kW), Oi (4.71 bln) Fukushima-1 (4.696 bln), Fukushima-2 (4.4 bln). Japan is the global leader in terms of power supply lines density (with the overall length of 70 thousand km), and the country is ranked the global third in terms of electric power consumption per capita.

I was particularly interested in information on coastal residents, who were hit by the tsunami wave of destructive and remorseless force. News releases were grim - tens of thousands people were reported missing (over 25 thousand including the dead).

Then, information came about troubles at Fukushima NPP, caused by flooding of seawater to the NPP site. All Japanese NPPs are located

at the sea coast, as they use seawater to cool plant machinery. As a result, the industry designers have to protect energy facilities from both earthquakes and tsunami. Tsunami protection walls at Japanese NPPs are generally 6 m high, so, if seawater entered the Fukushima NPP site, the tsunami wave was to be even higher. From media releases I got information on the 10 m high tsunami wave that made back-up diesel-powered generators inoperable - the ones designed to provide emergency power supply to the NPP that was already switched off from the regional grid at that time. Circulation of fuel-cooling water in 6 reactors ceased. Battery back up remained the only available source of power but battery capacity was sufficient to ensure only 6 to 8 hours of operation of low duty consumers only. A critical situation emerged at Fukushima NPP with a workforce of 800 - circulation pumps stopped, and as a result, temperature and pressure started to rise in steel pressure vessels of nuclear reactors that were left without cooling.

Kyodo news agency informed that in the morning of March 12, specialists were to start venting radioactive gases from the Unit 1 reactor, as pressure inside the unit gradually approached 150



Fukushima Daiichi NPP before the explosion.

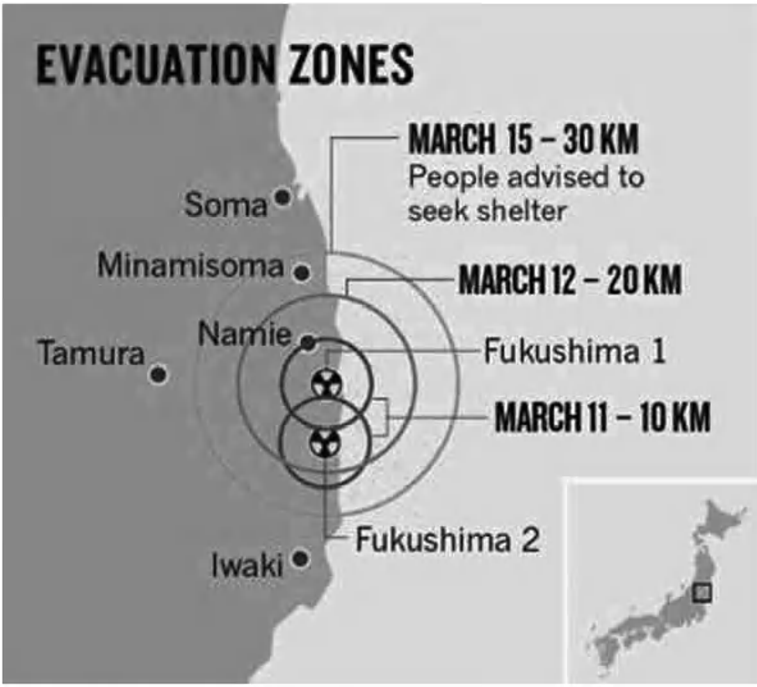
atmospheres. Authorities stated that no reactor explosion risks existed and that seawater was pumped by fire engines to three reactors units to cool nuclear fuel. Nuclear energy experts from different countries started to advice the press to avoid inflaming tensions and exaggerating. In principle, a nuclear power plant is the most heavily protected facility from any external impacts. Modern NPPs are designed to withstand effects of tsunami, tornadoes, falling planes and earthquakes. The most serious threat for a nuclear power plant is associated with releases of radioactive substances through protective barriers - four barriers in total. Such barriers - even the first one - are not expected to fail due to an earthquake.

Nuclear power plants in Japan were constructed taking into account seismic conditions of the country that is known to experience earthquakes fairly often, including powerful earthquakes as well. All Japanese NPPs are designed to withstand an earthquake with magnitude of 9 to 10 points Richter scale. On March 11, the earthquake magnitude in the epicentre (located in the open sea far away from the coast) reached 9 points. According to Vladimir Asmolov - the deputy Director General of Rosenergoatom Concern , Candidate of Sciences (Engineering) - even in the case of the maximal rated earthquake, radioactive releases are impossible, in such a case a power plant may only bear some economic losses. But reality does not always go in line with experts' forecasts. On March 12, the events take the following turn:

At 04:40, 13-fold increase of radiation intensity was registered at Fukushima NPP.

At 15:39, a gas explosion damaged building of reactor unit #1 (hydrogen was vented from the reactor enclosure through a valve, hydrogen mixed with ambient oxygen, an explosive mixture formed, and the subsequent explosion destroyed the superstructure of the reactor unit).

At 20:20, a reactor cooling operation was launched, the reactor was cooled by seawater containing boric acid additives to reduce neutron flux density. The authorities declared evacuation of residents from 10-km zone.



Then, the nightmare started.

14.03.2011

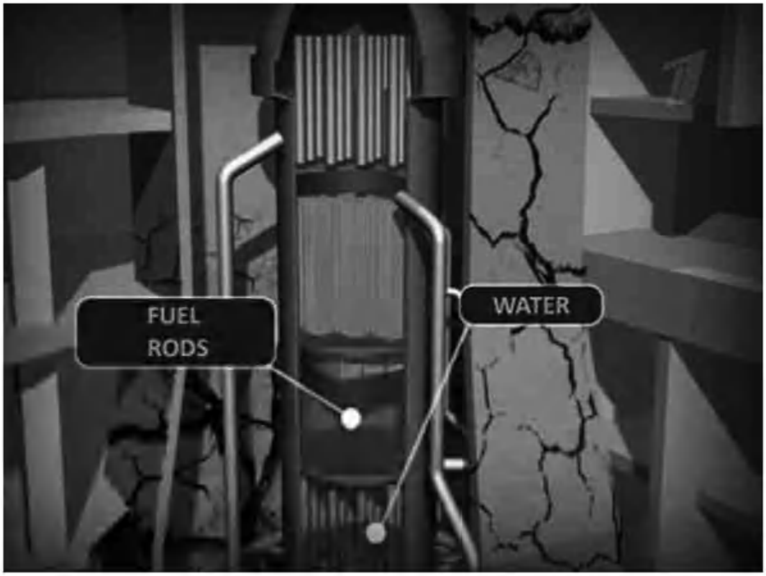
12:30 - Explosion in the building of reactor unit # 3, presumably caused by released hydrogen. The reactor building was destroyed.

21:37 - A record high radiation level was registered from the beginning of the disaster – 313 Roentgen per hour (3130 ìSv/h), the level was 500,000 times higher than the natural background (6 ìR/h).

15.03.2011

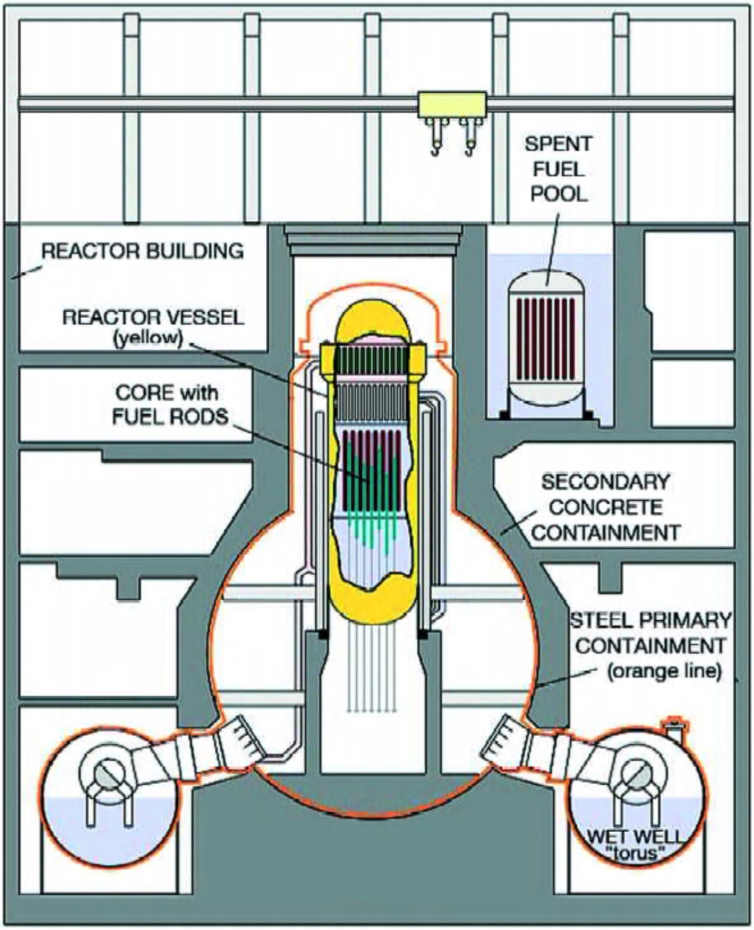
06:20 - Explosion in the building of reactor unit # 2. Explosion and fire in the building of reactor unit # 4.

09:00 - A new record high radiation level was registered – 1200 R/h (11 930 ìSv/h).



The cross-section drawing of damaged pressurised zone of unit #2

Reactors for Fukushima NPP were designed by General Electric Company (US). The reactors were rated to withstand an earthquake with magnitude of 7 points Richter scale. Steel reactor vessels were sealed by protective reinforced concrete enclosures to prevent releases of radioactive materials. The secondary enclosure (so called containment) is a rectangular construction that is shown in TV news footage. At the top roof of the containment, a steel assembly is installed for a crane to load/unload nuclear fuel.



Cross section drawing of a reactor unit with BWR reactor (Mark-1 reactor design)

Note: the reactor vessel is shown as a yellow cylinder. The internal steel enclosure of the protective sealing is shown amber.

Threshold temperatures of reactor materials

280 - 350 °C - standard operational temperature of fuel elements casing (zircaloy);

1450 - 1500 °C - reaction between zirconium alloy and steam with formation of hydrogen, embitterment of zircaloy starts ;

1500 - 1650 °C - the reaction between zirconium alloy and water vapour may become autocatalytic;

1600 - 1700 °C – melting temperature of the reactor vessel material;

1900 °C - melting temperature of zirconium alloy, when temperature increases to 2150 °C releases of fission products from fuel pellets substantially increase;

2800 °C - melting temperature of the nuclear fuel (UO_2).

Well, why did Fukushima reactors explode? Let us start examining.

At mid-day of March 11, 2011, seismic sensors of Fukushima-1 in Fukushima prefecture registered initial manifestation of a powerful earthquake. The facility was switched off the grid. The emergency back-up diesel-powered power supply system was switched on. Automatic reactor protection systems responded to alarms and started to insert control rods into all three reactors that were in operation at that moment.

Three minutes later, reactors generated only 10% of their rated power, while 6 minutes later the figure decreased to 1%. However, that does not mean that the reactors cooled immediately. For several initial hours after shut-down, nuclear fuel continues to generate substantial amounts of heat. The residual heat generation is caused by nuclear transformations in irradiated fuel. These transformations do not stop after reactor shut-down. The residual heat generation decreases only with reduction of levels of excited nuclei in fission products. The process needs some time, at least 10 days. Due to these reasons, continuous removal of heat (afterheat removal) is a key precondition for safe operation of a nuclear reactor. Modern reactors are equipped with efficient core cooling systems that are designed to remove heat from nuclear fuel after reactor shut-down. But reactors of Fukushima-1 NPP had not been cooled after the shut-down when the tsunami wave hit them.

10 m high tsunami wave easily crossed 6 m high tsunami barrier and disabled diesel-powered back-up generators that powered reactor cooling pumps. Circulation of cooling water in the reactor stopped. Temperature of nuclear fuel in the reactor started to increase causing evaporation of water. As a result, water level in the reactor decreased, this led to the exposing of upper sections of fuel rods, while pressure in the reactor vessel increased. When water vapour contacted zirconium casing, they started to react, generating hydrogen. There is a potential second source of hydrogen as well - water radiolysis, decomposition of water into hydrogen and oxygen under impact of intensive radiation.

Photo of Fukushima NPP, view from the ocean,
unit #1 is the rightmost.

Hydrogen generation caused growth of pressure in the reactor vessel (the pressure increased twice from the initial 70 atm), as a result, facility operators had to release reactor gases to the protective

Photo of Fukushima NPP, view from the coast, after the explosion
of March 15. Unit # 1 is in the left.

containment covering the reactor. These releases caused sharp pressure increase in the containment, necessitating release of hydrogen to the superstructure of the reactor unit. After mixing with oxygen from ambient air and reaching 4% concentration in the gaseous mixture, hydrogen-air mixture exploded immediately. Three first reactor units of Fukushima NPP exploded according to the same scenario. The only difference was associated with the fact that in the case of Unit 1 and Unit 3, hydrogen was vented from the reactor vessel through upper release valves to the containment and then to the superstructure, while in the case of Unit 2, hydrogen was vented to the toroid-shaped water reservoir (at the cross-section drawing the reservoir encircles the lower part of the reactor). As a result, in Unit 2, gas exploded in the lower section of the containment and had not destroyed the superstructure. However, in the latter case, the explosion damaged the reactor vessel and the reinforced concrete containment of the steel reactor vessel.

The fourth reactor was not in operation due to maintenance works and fuel was removed from the reactor. However, water circulation in the cooling pool of the irradiated fuel stopped and water started to evaporate from the pool. Later on, the situation followed the pattern of the first three reactor units: exposition of the fuel rods, reaction between zirconium and water vapour, accelerated generation of hydrogen, formation of hydrogen-air mixture and its explosion. The explosion destroyed the reactor unit superstructure and partly destroyed the cooling pool containing 1331 irradiated (spent) fuel assemblies.

The Fukushima accident differs from both accidents that happened at the Chernobyl and the Three Mile Island (US) NPPs. In the case of Fukushima accident, plant operators cannot be blamed, as they shut down all the reactors timely and the normal reactor cooling process was launched with application of in-built systems powered by emergency back-up (diesel-powered generators). The normal reactor cooling process failed only after the tsunami wave destroyed the power supply system of reactor units. Then, the situation evolved slowly but against the scenario, anticipated by the plant designers. In particular, they did not expect that in a few days after the accident, all external and emergency power supply sources of circulation pumps of NPP may fail. They provided an impressive stock of reserve pumps and generators, but unfortunately enough, all those were destroyed by the tsunami. Fukushima NPP was not prepared to withstand such a blow of 10 m high wave. The same tsunami wave affected another NPP as well - Onagawa NPP. In the latter case, a fire emerged in the NPP turbine block and radiation level exceeded the pre-accident background by 400 times.

Who is to be blamed

Was the accident caused by design of nuclear reactors and reactor units? The question was already answered by Dale Bridenbaugh - one of Mark-1 reactor designers, an engineer of General Electric Corp. 35 years ago he resigned due to his concerns about safety of the reactor that was later installed at Fukushima Daiichi NPP in Japan. After explosions at Fukushima NPP site he said that - so far as he knew - the NPP personnel addressed some design deficiencies, entailing "rather substantial costs". Now he believes that the situation at Fukushima NPP IS NOT a direct consequence of problems associated with the protective cover of Mark-1 reactor. The situation is a direct result of the earthquake, the tsunami and the fact that the protective cover of Mark-1 reactor is less fault-forgiving that some other reactor types.

Let me add only one consideration. The system of emergency back-up power supply of the NPP was not equipped by equally strong security barriers as the ones of the reactor the system was to protect in the case of accidents. As a result, diesel-powered generators of the emergency system were disabled by the tsunami wave. The reactors were left without circulating water cooling, that, finally, caused explosions at 4 reactor units.

I am not inclined to attribute the events that happened to operator's faults. They operate the equipment they were provided and have to follow manuals written for them. The actual accident was off-design, it was not anticipated in operation manuals. Therefore, after the accident it was the Crisis Management Team (CMT) that guided actions of the plant operators. Hydrogen explosions at reactor units were the result of the decisions made by the CMT. Should they immediately dewater the circuit and the reactor after the loss of cooling water circulation, steam-zirconium reaction and hydrogen generation would not happen. Pressure would not rise in metal reactor vessels. No gas discharges and explosions would happen. In addition, all safety barriers would remain intact, except casing of fuel assemblies and radiation would not be released to the environment, neither with gases, nor with water. However, all were afraid of a hypothetical fuel melt that might burn through the reactor vessel core, then through the containment and then into the open. As a result, all efforts were focused on cooling fuel in reactors by seawater. Pools with spent fuel were simply forgotten, while hydrogen generation started there as well.

The dreadful picture of a nuclear fuel melting, burning through the floor and escaping from the reactor was produced by old conservative estimates that seriously frightened politicians and some experts at the time of Chernobyl. At that time, the estimates initiated by

Academician Yevgeniy Velikhov of the Institute of Nuclear Energy (Moscow) suggested that melted nuclear fuel can remain liquid for many months due to internal heat generation. Such a melt was assumed to move gradually to the centre of the Earth, burning through everything on its way and descending at 1 m/day. It is necessary to note that this model was not developed by physicists, it was developed by mathematicians and laser specialists. They modelled the situation with an experimental device with permanent supply of energy for heating, thus maintaining (artificially) the temperature necessary to confirm their conclusions. Anyway, one may read about these events in: Rafael Arutyunyan. The China Syndrome. “Priroda”, # 11, 1990 (in Russian).

In 1986, these theoretical assumptions about the behaviour of nuclear fuel without cooling were not universally recognised, but politicians trusted them. Surely, leading nuclear powers now run powerful computers to model the situation but they do not produce convincing results. Why so? Because two things are needed - accurate data on accident parameters (temperatures, masses, pressures, moisture, amounts of water, etc. - such data are not available as all relevant sensors were destroyed), and a clearly confirmed existence of the melt (also unavailable yet). The fact that the fuel really melted in Chernobyl cannot be considered as evidence in favour of the above estimates. Yes, fuel in Chernobyl really melted, but melting did not happen because of the decay heat, it happened due to energy released by the nuclear explosion in the reactor. The Chernobyl meld did not burn through any constructions under the reactor. It slowly flew, engulfing different materials in the process and then its “tongue” had peacefully cooled in water of the pressure suppression pond. Its entry to the pond was not caused by a burn-through, the melted mass flew through the open steam relief valves and had frozen there as wide snags.

Therefore, the reactors should be safely dewatered and water should be pumped by fire engines only to the cooling pools with irradiated fuel to avoid their explosion. I described the strategy to Moscow office of Japanese Mainiti Newspaper on March 15. I wanted to warn Japanese specialists on dangers of using water to cool the reactors, as fire engines cannot ensure complete reactor filling by water and to prevent the steam-zirconium reaction. They were teetering at the brink of explosion all the time and finally the explosions happened.

Besides all other things, application of sea water sharply decreases the threshold temperature of steam-zirconium reaction (down to 300ÎÑ) from 800 ÎÑ in the case of fresh water. The latter factor increased probability of repeated explosions but fortunately they did not happen.

The frozen melt under the reactor of Unit 4 of Chernobyl NPP

The error of the accident mitigation personnel - choosing the strategy of pumping seawater into the reactors instead of their complete dewatering - resulted in destruction of safety barriers and radiation releases from reactors, power generation units and the NPP site. The disaster could had been avoided by swift dewatering of active core zones immediately after the circulation failure. As the Chernobyl accident demonstrated, afterheat (decay heat) alone cannot melt the fuel (2800 ÎÑ), nothing to say about its boiling (4000 ÎÑ). While working in Chernobyl as the Deputy Chief Engineer on Research and Nuclear Safety, I examined photos of fuel assemblies thrown out from 4th reactor by the explosion. In the course of cleaning roofs nearby Unit-4, fuel rods were found even inside channel pipes with graphite blocks on them. But none of the fuel rods was melted by residual heat. Yes, the assemblies were damaged by the explosion. Yes, some were non-hermetic and some were partly fused by the explosion. But that was all. As a result, I am sure that after quick dewatering of Fukushima reactors, maximum impacts would be limited to local losses of zirconium casing of fuel rods and partial destruction of fuel pellets. In such a case, all radiation would be contained in the steel reactor vessel. I was sure that the fuel melt could not form in the reactors due to lack of the chain reaction - the main source of energy. A similar situation was observed in the case of Three Mile Island NPP accident.

Photo of damaged but unfused fuel rods in the reactor of Three Mile Island NPP (US, 1979).

What do the Japanese have now? They have radioactive contamination of the NPP site and adjacent areas by strontium, caesium and plutonium, in addition to gas emissions from reactors that also contained radioactive isotopes. Sites of reactor units and the ocean are contaminated by water, that was discharged after surface cooling of destroyed reactor units by water cannons of fire engines. The bulk of radiation in the reactor section of the plant is generated by fuel cooling pools that lost water due to evaporation (water there served as a biological protection shield). The pools did not have other protection except 5 m water layer over the rods. Evaporation of water meant evaporation of the protection shield. Thousands Roentgens/ hour started to irradiate the surrounding area from above (the pools are not located at the ground level, they were built at the level of the upper part of the reactor vessel, outside the plant pressurised containment).

What should be done with the contaminated water? They discharged water to the ocean, and now one can hardly do anything to address the problem. It is necessary to restore the normal water supply of the plant, to restore its mainstream technological circuits, to control water levels in cooling pools with irradiated fuel. It is necessary to reduce discharges of radioactive water to the ocean by all possible means. All other objectives are secondary priorities, as the reactors of Fukushima-1 NPP have been lost irreversibly.

I assess actions of all liquidators, including fire-fighters, policemen and rescuers as heroic. However, they do not decide - decisions there are made by the CMT. So, it is the CMT that should be responsible for explosions - the one that already happened and the ones that may happen.

How did the Crisis Management Team work? Two initial days were almost the most important days of the accident at Japanese NPP “Fukushima Daiichi”. Bloomberg News Agency described what happened at the plant and around it at that time:

“Kazuma Yokota, 39 years old, the inspector of the Nuclear and Industrial Safety Agency (NISA), at the moment of the earthquake on March 11, hiding in his office under the table, afraid that the ceiling might collapse.15 minutes later, he arrived at the Western gate of the plant. He was accompanied by thousands of people in coveralls who were on their way to emergency evacuation points. 43 years old technician Kazuhito Matsumoto was among them. The earthquake hit when he was in the turbine building of Unit-6. Light went off and only green “Exit” signs were illuminated. The loudspeakers ordered to leave the facility.Overall, on March 11, there were 6415 people at the NPP site. More than 5500 of them, including Matsumoto, were employees of subcontractor companies. A quick head count made clear that 6413 persons are alive. Two TEPCO employees were missing.

A few initial minutes of panic were followed by temporary calm. Only cracked pathways and broken windows reminded about the earthquake. However, all six unit structures remained intact. Three operating reactors were shut down by the safety system.

Yokoka and six his colleagues from NISA visited the NPP in the framework of a regular quarterly inspection. At that time, they did not know that the earthquake damaged the transformation substation located at the distance of 10 km from the site. External power supply to the plant was endangered and soon it was switched off.

Subcontractors’ personnel, including Matsumoto, went home. Yokota and two other inspectors went to Okuma - a small town 5 km away where NISA Crisis Centre for emergency response actions was located. Fifteen minutes later they reached the centre, the picture they saw was grim - the office was destroyed and its power supply and communication equipment were disconnected.

“For an hour or even two we could not contact anyone. I thought that we seem to have a problem”, - Yokota recalls.

The Crisis Management Team assembled in the quake-proof bunker at the NPP site. The CMT was headed by Masao Yoshida, the plant director and two his deputies - Masatoshi Fukura and Atsufumi Yoshizava. The bunker with white walls was connected by a hot line to TEPCO headquarters in Tokyo. Super strong walls and two filter systems in the bunker provided a reliable protection to people inside.

Inspector Yokota believes that 56 years old director Yoshida knew the plant from top to bottom and was prepared to lead the Crisis Management Team. Yoshida is one of the most experienced Japanese NPP directors.

In the national group that studied problems of extension of operational service life of NPP reactor units, Yoshida was the deputy chairman. The team is chaired by 70 years old honourable professor of Tokyo University Kenzo Mia. He characterised his colleague as follows: "Yosida is not a person who is afraid to deliver a bad news".

Power supply was the first priority problem faced by the Crisis Management Team at the NPP site. The external power supply line was disabled. Yoshida could rely on 13 diesel-powered generators, with dimensions of a railway locomotive and generation capacity of 6 MW each. "When a generator is switched on, it is extremely noisy, you cannot pass it by without earplugs", - Yasuo Arai from TEPCO PR dept. said, a former engineer.

The majority of personnel members left the site. The remaining ones conducted checks and routine procedures indoors. As a result, almost nobody of them saw the moment when the tsunami wave came. One engineer, who was at that time in Unit 5 or 6 building sincerely admitted that he failed to understand what had happened.

The tsunami completed the work started by the earthquake. Water wave overcame engineering protection barriers. 12 of 13 diesel generators were disabled, switchboards were also affected. Entry of seawater caused multiple short circuits.

"In one of turbine houses, water raised to 1.5 m from the floor level" -Hikaru Kuroda said, a member of TEPCO reactor team. The situation at Fukushima Daiichi NPP started to reach the scale of an accident.

By 15:41 local time of March 11, the plant relied only on backup battery power supply. At that time, they had no other sources of power supply. TEPCO had immediately notified the Government that the plant encountered SBO event (station blackout), or complete loss of power for the plant's own needs.

The plant could operate by battery power for 12 hours only. "The countdown started. Batteries offered the last hope that a miracle might happen. However, should the rescue cavalry arrive late you will face really serious problems" - Professor Edward Morse from California University commented.

However, TEPCO engineers could not ascertain clearly whether the batteries really worked. After the tsunami, some instruments were disabled making the plant personnel half-blind. "We lost ability to assess efficiency of the cooling systems as flow meters of Unit 1 and Unit 2 failed. And we still do not know why" Kuroda said.

By 16:36 local time of March 11, TEPCO had to admit that they lost control over the plant reactors. Nine minutes later the company notified the Government on the matter.

At 19:03 PM Naoto Kan (Prime Minister of Japan) declared the state of emergency. They started to prepare evacuation of local residents from the vicinity of the damaged NPP.

Meanwhile, TEPCO engineers tried to address another equipment failure - they could not measure water levels in Unit 1 and Unit 2 reactors. The *malfunctions were finally repaired. Water levels were found to be stable, meaning that the battery backup worked.*

In the morning of March 12, water level in Unit 1 reactor started to decrease. At 8:36 it reached the fuel level. Four hours later, the upper section of fuel assemblies (1.7 m high) was exposed. What happened later is well known.

Professor Morse believes that even initial reactor explosions still did not make the situation exceptional: "I could safely describe it as a minor accident of LOCA type". However, the fire in the area of spent fuel pool of Unit 4 changed the situation substantially and made the Japanese NPP accident extraordinary, unforeseen by Japanese nuclear safety manuals".

It is not a pleasant thing to say, but Chernobyl lessons did not teach many to value our life and safety. NHK journalists managed to get a shocking information. They found that by far not all accident liquidators were supplied with individual dosimeters even when they work in the hazardous zone. That is an absolute breach of state-set rules, and TEPCO managers complain that they lost many measuring devices due to the tsunami. NHK said that often only team leaders had dosimeters, while ordinary workers often had no idea of their own radiation exposure. TEPCO managers argue that workers without dosimeters were involved only into work operations at areas with low radiation levels.

I have to comment again on the reactor cooling - should a built-in circulation system fail, fuel cannot be cooled by fire engines. Reactor cooling requires hundreds of times higher flow rates. As a result, interruptions in water supply inevitably happen, fuel will be exposed and hydrogen will be generated. Then, pressure will rise and explosions will happen.

All estimates that suggest potential fuel meltdown are based on calculations only. Practice shows that decay heat alone cannot melt the fuel. To reach the melting point, the self-sustained fission chain reaction of uranium nuclei is necessary. Yes, fuel rods might depressurise, yes, the fuel assembly (fuel rod) core might rupture. Yes, fuel pellets can burst out from fuel assemblies (approximately a day after). Nobody has ever observed a fuel melt caused by decay heat, while there were multiple cases of fuel spills at nuclear facilities of the former USSR Ministry of Medium Machine Building.

Some comments on tsunami. Did Japanese specialists know that a tsunami wave after a quake may be higher than 6 metres? Yes, they knew. But they have done nothing to ensure protection from such a wave. Japanese authorities were aware of a possibility of a particularly powerful earthquake sometime around 2011. Many years ago they received such information from Russia.

“Kanto district in Japan will be prone to seismic activity with magnitude of 10 and higher in 2011” . The forecast was made by Valeriy Abramov in his research paper published 14 years ago. At that time, in 1997, the professor from Vladivostok did not intend to frighten anyone, he simply warned the Japanese on the imminent disaster.

Quakes hit India, Indonesia, New Zealand and now Japan. According to the scientist, the Earth had entered the so called destructive development cycle, when accumulated underground energy needs to be released. Such events follow their own regular cycles. These considerations form the underlying framework of Professor Abramov’s forecasting method : “the forecast covers four 22-year cycles. Coincidences are ideal, everything points at 2011”.

The Japanese responded to the Russian forecast only nine years after the paper was published. In 2006, they requested some clarifying documents and then went silent. Valeriy Abramov said: : “They were afraid of an earthquake, but they believed that their tsunami alert systems work perfectly. They did not expect that an earthquake near the Japanese Isles might generate such a powerful tsunami wave”.

Now, Valeriy Abramov, the Chief of the Regional Geology and Tectonic Physics Laboratory of the Pacific Oceanological Institute of the Far East Branch of the Academy of Science of Russian Federation, warns: “It is not just another earthquake that happened in Japan, it was the earthquake that marks the new stage and new realities of natural development. We have to account for the process”.

Valeriy Abramov gives a pessimistic short-term forecast for Japan - the new series of earthquakes will not cease soon - “They will be rocked for at least two months. The year 2011 has not finished yet, they are expected to encounter even more complex surprises from the Earth underground. This is our another forecast”.

If this forecast of Valeriy Abramov is correct, in new tectonic realities Japanese NPPs are practically doomed. This is the essence of Abramov’s words said openly - the nature alters its rules of the game and responses in a sharper and a stronger manner. All people, including the Japanese must be on alert! Quakes’ magnitudes may increase to 10, the height of tsunami wave may exceed 10 metres! Those who failed to understand and prepare themselves are doomed! The Japanese did not believe him and now they face a nuclear disaster.

But the Chinese understood and now they hurriedly prepare to rise height of tsunami protection barriers at their new coastal reactor units...

The second point that should be emphasised is associated with equal levels of protection of reactors and associated safety systems that are designed to save reactors in emergency situations. It is like a submarine hull - it should be equally reliable in a latrine and in a torpedo compartment. Otherwise, the boat is doomed. In Chernobyl, after the explosion of RBMK reactor, its emergency cooling system was destroyed immediately and was buried under construction debris. It happened because the system was installed on the open platform near the reactor. In the case of Fukushima NPP, emergency systems (diesel-powered generators) were disabled due to the same reason - they were not adequately protected and were installed in the basement of the turbine house. And emergency cooling of the reactor in impossible without these generators.

Let us consider the situation at Fukushima NPP in late March (26.03.2011) using official IAEA data.

Water is continuously pumped to the containment of Unit 1 at rate of 7.2 m^3/hour, as a result, they managed to cool the metal reactor vessel down to 144 ^{0}Ñ. State of nuclear fuel and engineering constructions of the spent fuel pool of Unit 1 are unknown so far. Intensity of the exposure dose inside the unit buildings reaches 2380 Roentgen/hour (23.8 Sv/hour).

Seawater is continuously supplied to the containment of Unit 2 at rate of 20.4 m^3/hour, temperature of the reactor vessel metal casing reaches 100 ^{0}Ñ. Temperature of water in the spent fuel pond reaches 52 ^{0}Ñ. Intensity of the exposure dose inside the unit buildings reaches 158 roentgen/hour (1.5 Sv/hour).

Seawater is continuously pumped to the containment of Unit 3 at rate of 14.4 m^3/hour, temperature of the casing of the reactor vessel reaches 102.5 ^{0}Ñ. Water temperature in the spent fuel pool reaches 52 ^{0}Ñ. State of nuclear fuel and engineering constructions of the spent fuel pool of Unit 3 so far are unknown. Intensity of the exposure dose inside the unit buildings reaches 130 Roentgen/hour (1.3 Sv/hour). Since 01:00 of this day (Kiev time) white smoke is periodically released from the unit building. Water inside the unit building is contaminated up to 3.9õ10^6 Bq/cm^3.

Status of nuclear fuel and engineering constructions in the spent fuel pool of Unit 4 are still unknown and uncontrollable. Personnel continue to pump seawater to the pond. Since 01:00 of today (Kiev time) white smoke is periodically released from the unit building, as in the case of Unit 3.

Photo of Unit 3 of Fukushima NPP

See below the information on filling the on-site spent fuel pools by nuclear fuel at Fukushima NPP (data for March 11, 2011):

	Pool capacity, rods.	Actual load, rods.
Unit 1	900	**292**
Unit 2	1240	**587**
Unit 3	1220	**514**
Unit 4	1590	**1331**
Unit 5	1590	**946**
Unit 6	1770	**876**

The third unit of Fukushima NPP was loaded with MOX fuel (plutonium-based). In terms of potential radiation impacts, that type of fuel is several orders of magnitude worse comparatively to the standard uranium-based load (but only in the case of damage of the reactor casing and release of the fuel fission products). Quality and quantity of decay products in the case of plutonium fuel are approximately the same as in the case of uranium fuel (caesium, strontium, iodine, etc.) The main problem is associated with the fuel element itself - plutonium is much more toxic than uranium, particularly in case of respiratory exposure. In addition to its toxicity and a half-life of many thousands years, plutonium is alpha-active.

Victims of tsunami in Japan get assistance from all possible sources, even from criminals. Reuters news agency managed to find that famous Japanese Yakudza regularly ships humanitarian aid to affected areas. Experts estimate that water, food, blankets and other necessities were worth at least $500 thousand. Writer Menebu Myadzaki shares his opinion on the matter: “Yakudza are outcasts. Being hounted people themselves they try to help others in distress. If they help people, even policemen could hardly blame them”.

By the way, it is not the first humanitarian mission of Japanese mobsters. In the course of Kobe quake in 1995 they also actively assisted victims. Sometimes they responded even quicker than rescuers.

General description and status
of Fukushima NPP reactor units *(according to IAEA data)*

#	Unit description and parameters	Description and status of reactor units of Fukushima NPP (Japan)					
		Unit 1	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**
1	Reactor type, design series	BWR/3 boiling water	BWR/4 boiling water	BWR/4 boiling water	BWR/4 boiling water	BWR/4 boiling water	BWR/5 boiling water
2	Reactor type, design series	1967 1971	1969 1974	1970 1976	1973 1978	1972 1978	1973 1979
3	Operation of the emergency cooling system	Failed	Insufficient, loop				Full
4	Thermal and electric capacity, MW	1380 MW 460 MW	2380 MW 784 MW	2380 MW 784 MW	2380 MW 784 MW	2380 MW 784 MW	3290 MW 1100 MW
5	Pre-accident status	Opera-ting	Opera-ting	Opera-ting	Shut down for maint-enance	Shut down for maint-enance	Shut down for maint-enance

#	Unit description and parameters	Description and status of reactor units of Fukushima NPP (Japan)					
		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
6	**Current active core status in the reactors and status of on-site spent fuel ponds by 07:30 21.03.11**						
7	Reactor core	Partly damag-ed	Partly damag-ed	Partly damag-ed	Unloa-ded	Secure cooling	Secure cooling
8	Spent fuel pools	Filled by water, damag-ed	Filled by water	Partly damag-ed	Heavily damag-ed	Secure cooling	Secure cooling
9	1st circuit	Damag-ed	Unpre-ssuriz-ed	Dama-ged	Status unkno-wn	Intact	Intact
10	Protective enclosure (containment)	Damag-ed	Unpre-ssuriz-ed	Destro-yed	Status unkno-wn	Pressu-rised	Pressu-rised
11	Unit superstructure	Destro-yed	Dama-ged	Destro-yed	Destro-yed	Intact	Intact

From the blog of a 19-year old plant operator, who works at Fukushima 2 NPP to mitigate consequences of the accident:

- "We worked there. We knew the situation. Therefore, we are guilty".

- "We have to stabilise state of the plant. We are like emotionless mechanisms. They say "go" and we go. They say "make the impossible" and we do".

- "I was impressed by words the Director said today: "Those who work at Fukushima Dai-itci and Dai-ni do not have human rights!!!".

His father also works at the plant. He said - "The only thing worth worrying now is a death from work overload".

In April, Kyodo News Agency admitted that daily radiation doses at the distance of 30 km to the north-east from the damaged plant exceeded the annual natural radiation background. The Government of Japan decided to extent the evacuation zone up to 30 km from the NPP site.

Let us return to causes of the accident and works at Fukushima NPP site.

In late June, The Wall Street Journal published results of its own investigation of causes of the accident at Fukushima 1 NPP after the tsunami generated by earthquake of March 11.

The newspaper managed to identify and interview tens of persons, including high rank officials, who in different periods of time were responsible for design and maintenance of the emergency back up power supply of the NPP and for the safety of the plant. The newspaper managed to identify a precise cause of the failure to start emergency cooling systems, that caused active core meltdown in three reactors - it was inadequate installation of "table-sized" instruments. Moreover, the newspaper emphasised that the critical vulnerability described above was well known for long time and it was even eliminated in newer reactor units of Fukushima NPP (the latter ones were safely shut down on March 11 in the emergency mode). The interviewed attribute the failure to address the problem for many decades to a mix of self-complacency, cost reduction measures and lack of attention of regulators.

The Wall Street Journal traced roots of the nuclear accident, compatible only with the Chernobyl disaster, to 1960s, when first Fukushima reactors were built. Japan had just recovered from consequences of the Second World War and, naturally enough, the country did not have a national school of NPP design. As a result, Mark 1 reactors were built by US specialists, relying on the design of General Electric Corporation. In contrast to modern NPPs and newer Fukushima reactors, pressurised containments of Mark 1 reactors are very small and tightly packed - actually they may accommodate only the reactor vessel and the most critical service systems. At that time designers justified such a solution by the need to reduce construction costs.

The protected constructions could not provide enough space neither for emergency back up generators, nor for the electric switchboards. For decades, these installations were accommodated in light outhouses that were swept by the tsunami. "TEPCO had to reconstruct these emergency back up systems to a new design" - 88-years old Masayoshi Toyota said, former top manager of the company and the supervisor of the NPP construction works.

He also blames himself for the failure to address the problem. "For many years, many designers many times proposed measures to enhance safety. But I think that none of them had finally succeeded to attract attention of top managers, as modernization of old reactors to meet new requirements is a rather expensive option" - Masagoshi Toyota said. Besides that, in 1980s TEPCO was under serious criticism for its high electricity prices and the company did not want to bear such additional costs.

Anyway, in 1998, TEPCO installed additional diesel-powered generators at Fukushima-1 NNP site. The generators were installed in stand-alone buildings farther away from the sea coast. But switchboards of these generators - those very "table-sized devices", remained in basement rooms of scarcely protected turbine houses.

As a result, on March 11, when Fukushima 1 NPP was struck by the tsunami some 45 minutes after 9.0 magnitude quake, seawater disabled external power supply to the plant and to its emergency control centre. In addition, seawater flooded emergency generators installed in 1970s. New emergency generators were not affected, they were started normally and began working. But is was in vain: while the switchboard design explicitly stipulated distribution of emergency power supply between all four cooling systems of old reactors, the systems were flooded with turbine houses. As WSJ quoted Kathui Tamono, former executive vide-president of TEPCO: "If water enters that place, everything is finished" -

TEPCO documents reveal chaos at the plant after the earthquake and the tsunami.

NHK WORLD news agency (May. 17th, 2011) informed that TEPCO issued 2900 pages of documents with description of situation at the moment of disaster and its further development. According to these documents, at 2:46:46 p.m. , 1st to 3rd reactors units were shut down by emergency procedures and then the duty personnel received numerous automatic messages on problems with insertion of control rods to reactors (control rods absorb neutrons and halt fission reaction). Nevertheless, emergency reactor cooling systems started to work. In 10 minutes after their launch, pressure in Unit 1 decreased from 70 atm to 45, that, according to manuals, suggested too intensive loss of heat by the fuel and required to switch off the emergency cooling. The duty NPP personnel did it.

At 3:30 p.m. the first tsunami wave struck the plant, cutting off all external power supply cables, damaging diesel-powered generators and flooding some sections of back up batteries. Only at 5 p.m. TEPCO ordered to deliver all available truck-mounted diesel generators from the company's facilities nearby the NPP. However, due to damaged roads and congestion, truks could not reach the plant. At 6:20 TEPCO asked Tohoku Electric to provide generators.

At 9:15 p.m. workers tried to release growing steam pressure at Unit 1 reactor, but the operation was cancelled due to high radiation inside Unit 1 building and they managed to complete it only by 10:17 p.m.

At 9:51 p.m., TEPCO Director Masata Shimizu issued the order prohibiting entry to Unit 1 building.

At 11:00 p.m. generators supplied by Tohoku Company arrived at the plant. By 3 a.m. of March 12, workers managed to connect generators to provide power to the NPP, but at 3:36 hydrogen exploded at Unit 1.

In the morning of March 12, at 9:15 workers tried again to vent pressure from Unit 1 reactor. Similar work was done at units 2 and 3 from March 13 to March 15.

Seventy mobile Army generators were delivered to the NPP after the destruction of external power supply cables. However, debris around the reactor units and flooded power supply switchboards did not allow connecting these generators, to power emergency cooling systems.

Only after 24 hours they managed to install an alternative system of cables to connect the generators to Unit 2, but hydrogen explosions at Unit 1 damaged the new cables.

The second explosion at Unit 3 reactor damaged several mobile generators by construction debris. As a result, power supply at the station was restored only by March 21.

In addition, TEPCO disclosed that 10 minutes after the quake the system of steam cooling condensers at Unit 1 went out of operation and did not operate for 3 hours. The operator said that workers switched the system off manually due to low pressure inside the reactor vessel and concerns about its possible damage. After the emergency shut down, pressure in the reactor decreased from 75 to 40 atm and according to manuals the system of emergency condenser cooling should be disabled.

The operator also admitted that the tsunami destroyed batteries at units 1 and 2.

It was merely the beginning of the accident. In April, radioactive contamination reached Tokyo. In districts of metropolitan Tokyo (Koto and Chioda) caesium activity in soil samples varied from 2000 to 3200 Bq/kg.

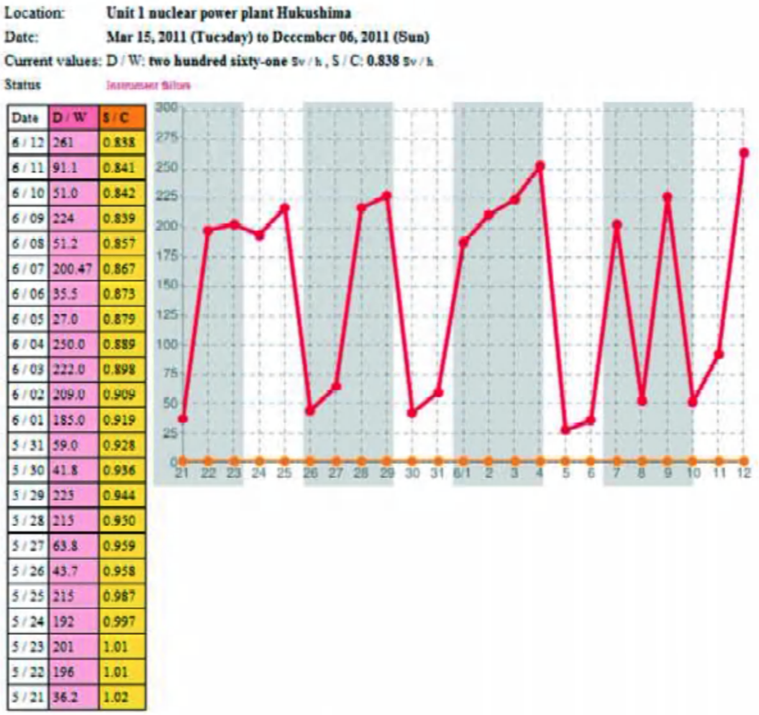
The saddest conclusion is that the accident is far from its end. It is on-going and now one cannot claim that Fukushima reactors are safe.

Let us consider Unit 1 in late June. Radiation intensity in reactor 1 reached 261 Sv/h.

The figure below suggests that the nuclear reaction of fission of fuel nuclei occurs in the rector. In addition, pressure inside the reactor vessel decreased to the level of ambient atmosphere pressure - an indication of ruptures in the reactor casing and its containment.

Growing radiation levels indicate that efforts to control fuel inside the reactor and prevent it from becoming critical are futile. Fukushima staff had made the situation unmanageable by its water pumping actions. Intensity of radiation from the reactor itself and radiation levels outside Unit 1 do not decrease, they grow - just another indication of its continuing criticality. Peak releases of radioactive iodine-131 also confirm periodic criticality of the reactor.

Those peak releases did not end on June 12, they continued. It seems that the Crisis Management Team intends to tease the radioactive “dragon” till it bites everybody. Just one example. In August, the company - operator conducted regular tests of instruments measuring depth of insertion of control rods at Unit 1 reactor and only one of these instruments was found to be functioning. The instruments’ sensors were obviously damaged by output surges. There is nothing surprising, as in May, June and July, actions of the plant personnel many times caused rise of output power of Unit 1 reactor. Nuclear fission generates extremely high temperatures that - unless adequate heat removal is secured - can melt the fuel and burn through the steel casing of the reactor vessel. See the chart below with radiation intensity peaks, following output peaks.



Date	D / W	S / C
6 / 12	261	0.838
6 / 11	91.1	0.841
6 / 10	51.0	0.842
6 / 09	224	0.839
6 / 08	51.2	0.857
6 / 07	200.47	0.867
6 / 06	35.5	0.873
6 / 05	27.0	0.879
6 / 04	250.0	0.889
6 / 03	222.0	0.898
6 / 02	209.0	0.909
6 / 01	185.0	0.919
5 / 31	59.0	0.928
5 / 30	41.8	0.936
5 / 29	225	0.944
5 / 28	215	0.950
5 / 27	63.8	0.959
5 / 26	43.7	0.958
5 / 25	215	0.987
5 / 24	192	0.997
5 / 23	201	1.01
5 / 22	196	1.01
5 / 21	36.2	1.02

http://4.bp.blogspot.com/-TDhvmXpWHiI/TfTXwpQRAVI/AAAAAAAA D5w/Wo26gYcyF-E/s640/Unit_1_Nuclear_Power_Plant_261sv.png

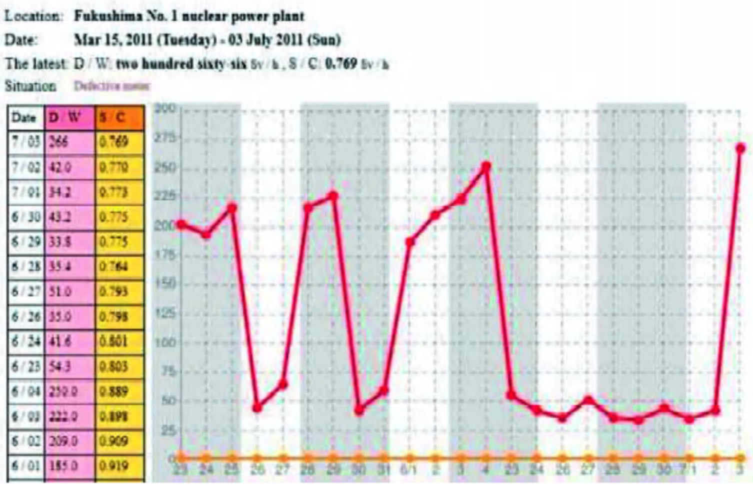
There is a vicious cycle - workers pump water to the reactor to cool its fuel down. But the result is opposite, as water at the bottom of the reactor vessel bunches fuel pellets together and - acting as a moderator

- ensures growing reactivity of the system. In May, five days of water pumping made the system critical and resulted in an output peak, heating the fuel (see May section of the chart). So, the CMT cooled the fuel for four days just to get it heated on the fifth days by a chain reaction of fission. After the output peak, they again pumped water to the reactor... up to a new peak. In June, the situation get even worse. Output peaks became more frequent and occurred every third day (see the right section of the chart). What comes then?

First, due to higher temperatures generated by a self-sustained chain reaction the fuel would really melt and the melt would really burn the reactor vessel through. There is water under the reactor. Depending on a relative mass ratio, the melt may either quickly freeze in the water (in case of its slow discharge) or may cause a steam explosion accompanied by radioactive "fireworks" if the reactor bottom will fall in one piece with sixty tons of hot metal. Second, even if reactor does not explode, such actions of the staff would finally contaminate Japan by continuous radioactive emissions.

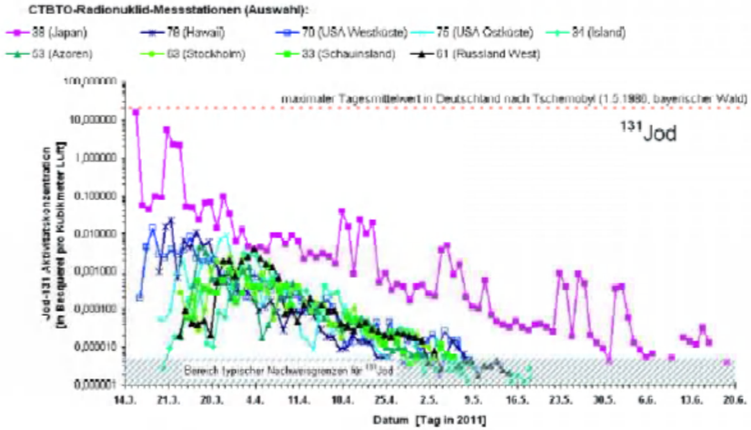
On July 3, the new maximum level of EDR was registered at Unit 1 - 266 Sv/hour (26600 R/h). *http://enenews.com/reactor-1-dry-meter-hits-new-high-266-svhour-japan-defective*

Adding boron earlier allowed suppressing output peaks only temporarily. The new peak was even more intensive.

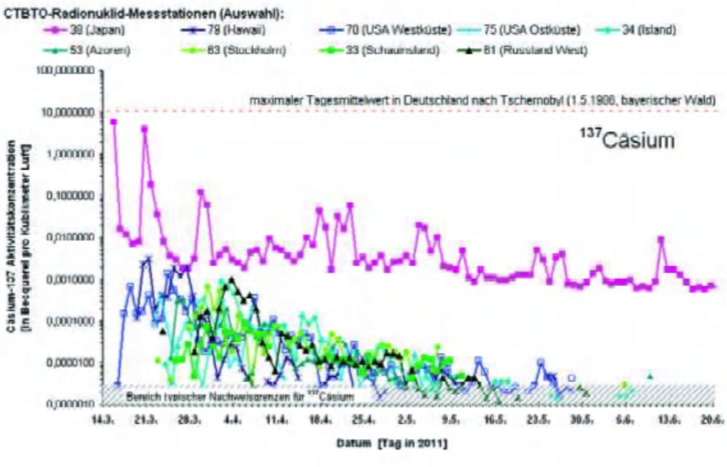


http://enenews.com/wp-content/uploads/2011/07/266.jpg

Output peaks led to releases of new portions of iodine-131, which travelled around the Globe and was registered even in Germany.



Fukushima iodine releases, in correlation with output peaks at Unit 1
http://www.bfs.de/de/ion/imis/ctbto_aktivitaetskonzentrationen_jod.gif



Caesium releases in Fukushima followed the same peak pattern
http://www.bfs.de/de/ion/imis/ctbto_aktivitaetskonzentrationen_caesium.gif

A question arises - what is IAEA doing? Why there is nothing like a scientifically substantiated program of actions for Fukushima CMT?

“It is rather hard for IAEA to analyse the accident at Fukushima 1 NPP in-depth and professionally, as professionalism of many agency’s specialists have been decreasing gradually for a long time “ - Vladimir Asmolov argues (a member of the International Advisory Group on Nuclear Safety under the IAEA Director General, the deputy Director of “Rosenergoatom” Concern). “I think that IAEA cannot make a detailed analysis of the situation at the Japanese NPP, as qualification of the Agency’s officials substantially degraded” - Asmolov said. In addition, he noted that the Agency and its Director General Yukiya Amano still have not answered some difficult questions that emerged after the Japanese NPP accident, notwithstanding that the accident had happened three months ago (Jun. 24th, 2011 at 11:07 AM *http://www.atominfo.ru/news7/g0318.htm*).

So one should not be surprised to find that information on the Fukushima tragedy is downgraded and distorted in Japan and elsewhere. Just one example. Canadian newspaper The Beacon published (Jun. 21st, 2011 at 4:37 PM *http://www.ganderbeacon.ca/News/2011-06 ... -worries/*1) information on farmers from Newfoundland and Labrador, who tried to check their products for radionuclide contents. Farmers approached both government agencies and private companies but in all cases their requests were refused. The refusals were substantiated similarly - as Health Canada stated that no changes of radiation background were registered, we would not carry tests. While Newfoundland is considered a safe area, numerous media reports suggest that background radiation levels there doubled recently. According to a CNN report, Arny Gundersen, the Chief Nuclear Engineer, said that hot particles appear permanently in North America. He explained that radiation is emitted by a huge gaseous clouds, that is registered by a Geiger counter. In addition, engineers-physicists also register hot particles that might cause human cancer cases worldwide. In April, measurements in Tokyo suggested that an ordinary person might have respiratory exposure to about 10 hot particles/day. In Seattle (US), the relevant figure reaches five hot particles per day. Such hot particles might remain deposited in lung tissues, in gastric-intestine tract, or in bones and cause cancer after many years. Mr Gundersen suggested only one safety precaution - to wash all fruits and vegetables carefully before use.

Scientist and engineer Marco Kaltofen studies flows of these migrating hot particles. His research of areas of radioactive deposits and follow up of their long-range travel suggests that such nano-particles really contain highly radioactive substances but due to their small sizes they cannot be registered by a standard Geiger counter. Mr Kaltofen noted that there are short-term radiation impacts (e.g. X-rays) and long-term ones - in the latter case particles might carry substantial amounts of radioactive emitters that never leave a human body. He said that regardless of particular locations of their deposition in a human body, they damage tissues and kill human cells.

Media reports suggest that Japan underestimated gravity of consequences of the accident from the very first day of the disaster. But the Public Health Ministry insists that residents have no reasons for concern.

I have to admit, that the same situation was observed after the Chernobyl accident. Hot particles flew everywhere but the authorities pretended that such particles did not exist. To deprive opponents of objective evidence, top officials of the Public Health Ministry even prohibited post-mortem examination of lungs of dead liquidators. Today's public health ministries of Canada and Japan in their public information releases do not differ much from the USSR Public Health Ministry of 1986.

However, alternative opinions do exist. For example, Ichiro Ozava, a high profile Japanese politician, in his interview to The Wall Street Journal said that Fukushima may made the whole territory of Japan "unfit for life".

The scale of the accident is understated

On 12.04.11, Naoto Kan, the PM of Japan, said that his country did not attempt to hold back information on development of the nuclear crisis after the accident at Fukushima-1 NPP. However, neither media reports, nor TEPCO's press-releases said anything about high radiation levels at Unit 1 reactor. According to April measurements , radiation levels in the pump-room (in the containment) reached more than 10,000 R/h (over 100 Sv/h) while radiation level in the pressure suppression pool reached 1200 R/h (12 Sv/h).

TEPCO Corporation was aware of nuclear fuel releases from the reactor. Plutonium isotopes were found on March 25 and 28 in soil samples nearby Unit 1 reactor and its infrastructure. But TEPCO admitted only releases of radioactive iodine-131.

Later on, Japanese authorities admitted that they concealed some information on Fukushima-1 accident. According to Gohsi Hosono, an advisor to the Prime Minister, they did it to avoid potential panic.

The US also does not differ substantially from Japan. NRC document, dated March 26, provides detailed information on neutron sources, scattered at the distance of up to 1 mile from Fukushima reactor units. These sources - large pieces of highly radioactive materials - were later moved by bulldozers to the land area between Unit 3 and Unit 4. But IAEA and the US Department of Energy admitted possible plutonium leaks only on March 30.

As for radioactive water - notwithstanding threats of radiation for all living things, water from Fukushima NPP site was discharged to the ocean. It is still being discharged today and it will be discharged as long as possible. In addition to iodine, strontium and caesium, contaminated water contains also uranium dioxide with plutonium. I am sure that TEPCO will continue discharging polluted water unless the NPP site will come under control of a serious international organisation or commission to control its discharges.

Chernobyl polluted the whole world by its air emissions, while Fukushima did the same with its radioactive water discharges - **that is the only difference between them.** But the initial radioactive loads in Chernobyl were almost 10 times lower comparatively to nuclear fuel stock in 4 Fukushima reactors.

How much radioactive water does Fukushima produce? A rough estimate at the base of daily water intake might suggest that its amount had exceeded 400 thousand tons long ago. From that amount, at least 300 thousand tons were discharged to the ocean. And the estimate is based on incomplete data only. It is not a deadly blow to the world ocean, but marine food chains have been already fully affected. What is next? Look at the map of ocean currents and everything will be clear.

Three times more radioactive substances were released to the Pacific then TEPCO admitted

(Source: NHK, September 8, 2011). A group of Japanese researchers concluded that the overall discharge of radioactive elements to the sea from damaged Fukushima Dai-ichi NPP reached 15 thousand TBq. The figure is more than three times higher then information submitted by the NPP operator - Tokyo Denreky Company (TEPCO).

The group included representatives of the Japanese Nuclear Energy Agency and Kyoto University. The group collected data for a month, starting from late March. They accounted for amounts of radioactive discharges to the Pacific from the NPP site and results of seawater monitoring. The group emphasised that it is very important to know the amount of radioactive substances released to assess effects of the accident for the sea.

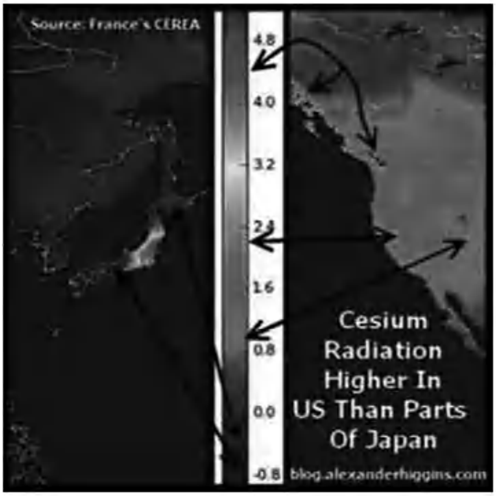
As I understand, 15 thousand TBq is not the final figure. Let us wait and see their cumulative data for the whole period, including contemporary on-going discharges.

Let us look at what experts say about Fukushima-related hazards [http://nnm.ru/blogs/inox777/protiv-molchaniya-i-lzhi-o-fukusimskoy-katastrofe/#cut%D1%97.

Nuclear expert Arnold Gundersen (Boston)

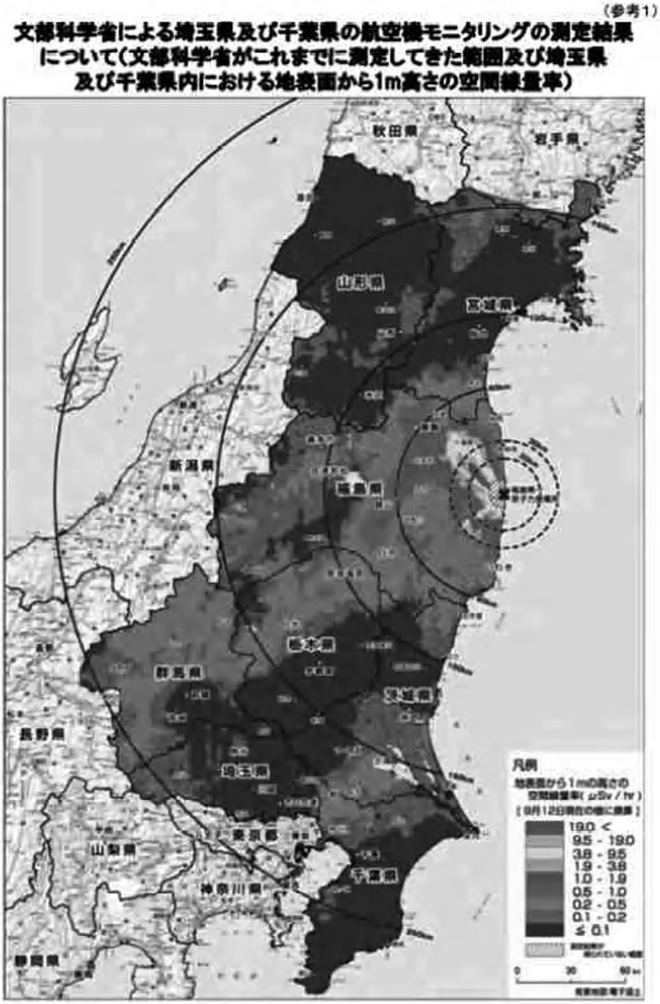
This highly experienced nuclear engineer from initial days of the disaster and up to now regularly provids numerous specific details associated with radioactive contamination and impacts of the accident at Japanese reactors. In mid-March he figuratively defined the Fukushima disaster as "Chernobyl on steroids". According to his information, a study of air filters made in April 2011 suggested that every average Tokyo resident daily "inhales" 10 hot particles containing caesium, strontium, uranium, plutonium, cobalt-60, etc.). Closer to Fukushima, relevant figures were 30 - 40 times higher. At the same time, in Seattle area (US) local residents inhaled 5 radioactive micro-particles daily.

These radiation sources are different comparatively to gamma-radiation of xenon and krypton isotopes. Almost 90% of radioactive substances still remain within the reactors and they are released to the environment with water or steam. Comparatively to background radiation, hot particles are difficult for detection (unless they are present in large quantities). Having deposited at human skin or in lungs, they "reside" there for an indefinite period of time and damage surrounding tissues and organs by alpha-radiation. It is rather hard to identify these internally deposited hot particles as they are shielded by surrounding body tissues. In this connection Gundersen recommends all people who deal with air filters to use protective face masks and gloves.



Simulated radioactive contamination map according to French research centre CEREA (source: http://cerea.enpc.fr/en/fukushima.html). Elevated radiation areas in Japan and in the US. http://img15.nnm.ru/3/4/4/a/0/07eee01280ef370e72236ff52f4.jpg

The total activity of isotopes released to the environment reaches over 1 GBq/day. The bulk of radioactive gases dissipate in the atmosphere and migrate worldwide with air currents. Pieces of plutonium-containing materials (up to 1 cm in size) were found nearby (destroyed) Unit 3 reactor. Any future earthquake of about 7.5 magnitude will inevitably



destroy remaining reactor buildings and increase radiation releases dramatically. A zone of heavy radiation contamination was found at the distance of 480 km from Fukushima. Earlier "clean" hay becomes radioactive due to depositions from atmosphere. As a result, meat and dairy products become dangerous. Huge land areas will become excluded from use for several decades at least. The author emphasises that the Government of Japan (the national elite) is doing nothing to raise awareness of local residents and evacuate them from affected areas.

Physician and anti-nuclear activist Dr Helen Caldicott, Australia

In her article "Why Fukushima Nuclear Disaster is Worse than Chernobyl" Dr Caldicott underlines that the accident at Fukushima NPP is not a merely environmental or economic crisis. Authorities keep silence about the fact that consequences of the disaster and its radiation releases will induce a global public health crisis, associated with higher incidence of cancer cases in the Northern hemisphere and many other adverse effects. Five to ten years in the future, today's contamination of food and water might cause development of malignant tumours, slowly and invisibly. Such a crisis does not recognise class differences - it will affect all, the poor and the reach alike, presidents and taxi drivers, geniuses and idiots, and others in-between.

In her opinion the disaster scale of Fukushima is worse than Chernobyl (below are some extracts from the article of Dr Helen Caldicott):

"Chernobyl resulted in spread of radioactive pollution throughout Europe. Elevated radiation levels are observed at 40 per cent of Europe' territory" - Caldicott said and added: "Products from Turkey are extremely highly radioactive". Having specified that the United State used depleted uranium ammunition in Falludjah and Bagdad, she stated: "80% of children there have severe birth defects, including missing brain, eyes, limbs - as a results, medics discourage women to give birth". Uranium use caused also a 12-fold increase of cancer incidence among children, Helen underlined and summed the situation up as follows: "It is a genocide, they wage a nuclear war in Iraq."

As for Japan, Dr Coldicott said that Fukushima-generated radiation levels at the North-east of Japan are many times higher than the threshold levels for evacuation of residents in the case of the Chernobyl disaster, so residents of the area must be immediately evacuated".

Truth about Fukushima gradually leaks to the public. On September 30, 2011, Kyodo News Agency admitted that governmental experts for the first time found plutonium outside Fukushima-1 NPP plant. Plutonium was registered in 6 points of Fukushima prefecture, including Iitate village, within 45 km zone to the North from the damaged NPP. A representative of TEPCO said that radioactive particles could be carried by wind or rainfall.

On October 1, Asahi newspaper reported that a heavy cumulative dose of radioactive caesium in Chiba and Saitama prefectures was shown at the radiation contamination map published by the Ministry of Science of Japan on September 29. These prefectures are near the residential districts of Tokyo and are separated from the damaged Fukushima-1 NPP by 200 km. Measurements of radiation intensity were conducted from September 8 to September 12 (from helicopters).

In Chiba prefecture, the highest levels of caesium-137 (from 30 to 60 KBq/m^2) were registered in northern districts (Kasiva, Matsudo and Nagareyama). Caesium-137 has half-life of 30 years.

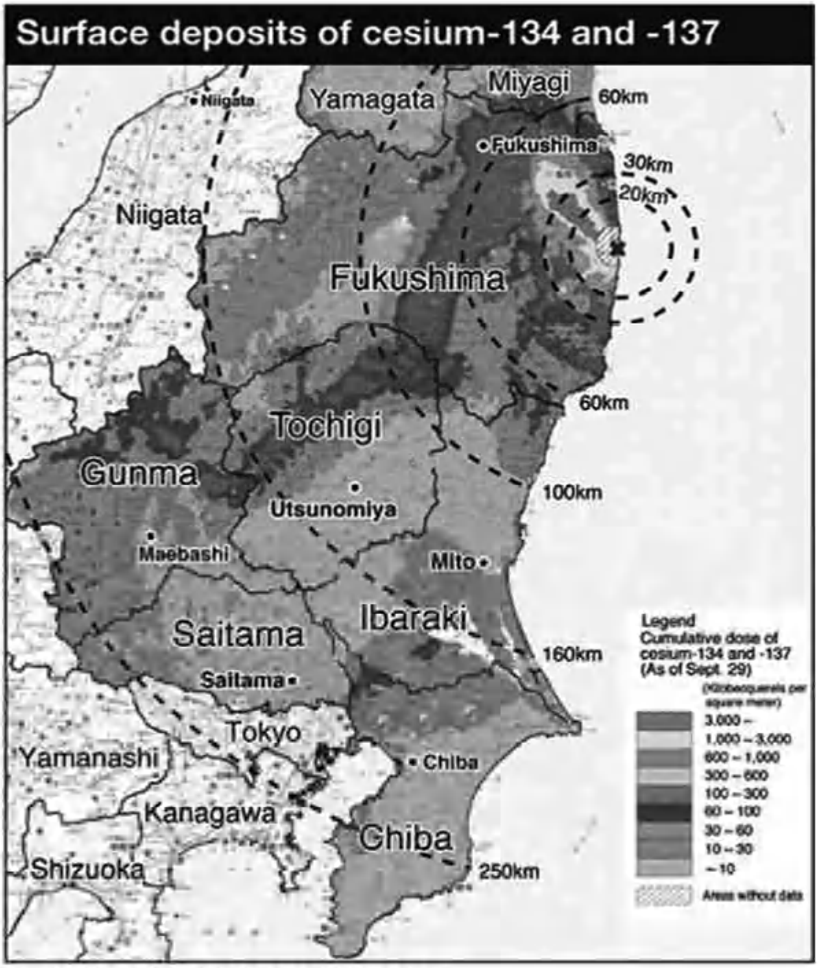
In several mountain districts of Saitama prefecture (located at the distance of 250 km) from the NPP, radioactive contamination levels also reached 30 to 60 KBq/m^2.

In the course of the Chernobyl disaster of 1986, areas with contamination of 37 KBk/m^2 and higher were declared zones of radioactive contamination, while radiation levels of 555 KBq/m^2 triggered mandatory evacuation of local residents.

The overall land area of Fukushima prefecture that should be decontaminated due to radiation releases after the accident at Fukushima-1 NPP reaches now about 2 thousand sq. km (or about a seventh of the total land area of the prefecture) - such a conclusion was made public at the expert meeting of the Ministry of Environment of Japan *[http://planeta.moy.su/blog/v_prefekture ... 09-15-6645]* **.** In terms of land area (13.8 thousand km^2) Fukushima is the third largest prefecture of Japan, after Hokkaido and Ivate.

According to estimates of Professor Yuiti Moriguti (Tokyo University), the amount of soil to be decontaminated due to high radioactive contamination would reach 100 million m^3. His estimates are based on the assumption that safe individual annual radiation level cannot exceed 1 mSv. As a result, he estimated that the area of 2 thousand km^2 should be decontaminated (or 100 million m^3 of soil). He assumed that radioactive caesium may be removed with 5 cm of the upper soil layer. Unfortunately, experience of Chernobyl suggests that later on such decontaminated areas become "dirty" again due to continued releases of radioactive materials from the destroyed reactor.

According to The Independent, Japan was reluctant to admit the real scale of the disaster, but now the truth slowly leaks out. In North-



Education, Culture, Sports, Science and Technology Ministry

east Japan, millions of people try to ascertain what a level of radiation may be considered safe, but in vain. "However, expert assessments differ radically, making people frustrated" - journalist David McNeil said. Fishermen from Soma (40 km from Fukushima-1 NPP) who survived the tsunami, wander when they will be able to resume fishing in the radioactively polluted sea.

Some experts argue, that the Fukushima disaster is even worse than Chernobyl. In particular, Australian physician Helen Coldicott warns that Fukushima will face a nightmare in the future. Chris Basbey from Ulster University predicts more that 1 million death cases:

“Fukushima still boils and bombards the whole Japan by its radionuclides. Chernobyl generated one single explosion, therefore Fukushima is worse”. The newspaper notes that Basbey is well know by his alarmist views.

These experts are confronted by specialists who assess the nuclear industry more positively. They assure that the situation is under control and radiation levels predominantly are not too high to be hazardous. Naoto Sekimura from Tokyo University believes that the national government and TEPCO make all necessary efforts to mitigate the disaster. The newspaper reminds that Sekimura initially informed residents of areas nearby the NPP that probability of radiation releases is fairly low.

“Japanese authorities slowly, gradually, but often with major delays reviewed their forecasts , making them more and more grim” - the newspaper noted. On the last Friday, experts who cooperated with the Nuclear and Industrial Safety Agency said that the NPP emitted to the atmosphere 15 thousand TBq of carcinogenic caesium - or about 168 times more that the Hiroshima nuclear explosion. Basbey believes that the contemporary radiation release is at least 72 thousand times worse than Hiroshima.

In September, Japanese authorities had finally admitted the fact that was known to their critics for a long time: thousands of residents of NPP-adjacent districts will be able to return to their homes not earlier than in 20 years. However, the most heavily disputed topic is associated with people who live outside the official exclusion zone. About 100 thousand children live in Fukushima city (63 km from the NPP site). Their parents demand the Government to implement additional measures for their protection. In schools, sport lessons in the open air were cancelled, schools work with windows closed.

There are some calls to evacuate all 2 million resident of Fukushima prefecture, but authorities so far do not consider such evacuation necessary. “According to the official point of view, the emergency situation at the NPP gradually becomes safer and radiation levels outside the exclusion zone, as well as some identified “hot spots” are harmless”.

Many experts warn that the crisis is only beginning. Biologist Tim Musso, who studied genetic effects of radiation nearby Chernobyl, had found that populations and species diversity of insects and spiders decreased, while some marked genetic anomalies were observed in the case of birds. Musso warns that long-term radiation impacts lead to rather substantial long-term adverse health effects.

Nuclear expert Steven C. Jones

In his interviews and a high-profile article "Fukushima Is the Heaviest Nuclear and Environmental Disaster in Human History" Jones noted:

"You do not see these radioactive particles, but it does not mean that they are not extremely dangerous. As an example of severe hazards of radiation I will only say that if 500 g of plutonium will be distributed evenly between lungs of all 7 billion people of the Earth, all men, women and children will die. Since March 11, tons of plutonium were released to the air and to the ocean (nothing to say about other radioactive elements). Another crucial fact - plutonium kills for millennia as its half-life is 24,500 years. Such elements as uranium have half-life of 4.47 billion years. Now, when all these elements are set free, the bulk of them will stay with us for the whole our lifetime, for lifetime of our children and grandchildren alike. Everything is much worse than they say!"

"Chernobyl was a mere picnic comparatively to Fukushima. The amount of caesium-137, already released by damaged reactors of the NPP is equal to 168 Hiroshima blasts. One should not also forget that Tokyo is located at the distance of only 250 km from Fukushima nuclear facilities".

"Nobody knows for sure what will happen with our oceans. However, according to Los Angeles Times, seawater nearby Fukushima plant is extremely radioactive. On August 30, Tokyo Electric Power Co. informed that levels of radioactive iodine-131 in seawater nearby the NPP site exceed relevant MACs by 7.5 million times… In other samples levels of radioactive caesium exceeded MACs by 1.1 million times".

"Mass media outlets are silent about all that radiation, but it does not mean that the radiation does not affect the United States. Fukushima-generated radiation was found in: algae of Puget Sound bay (the US Pacific coast), in drinking water and cow milk in many states of the USA. Very high radiation levels are still registered in rainfall at the North-West of the country. It is a slowly developing nightmare that will unfold for many years to come".

"Some experts argue that 50 to 100 years are needed to make Fukushima materials sufficiently "cold" for removal. So far, there is no efficient solution for Fukushima problem, so radiation will continue to escape from Fukushima reactors to kill millions of people worldwide, year after year".

In the US, physician Janet Sherman and epidemiologist Josef Mangano published their essay highlighting 35% peak growth of infant mortality in cities of North-western US, that happened after the Fukushima crisis and it is highly possible that the peak might be caused by deposition of radioactive substances from the damaged NPP.

Their report covered eight cities - San Jose, Berkley, San Francisco, Sacramento, Santa Cruz, Portland, Seattle and Boyce. The report covers nine weeks, immediately after the disaster.

Dr M.V. Ramana, a physicist of the Program of Science and Global Security (Princeton University), specialising in nuclear safety issues, said that he considers radiation levels within 50 km zone from the NPP hazardous for local residents. He added that the evacuation zone should be extended to the above limit.

A former nuclear industry insider, Arnold Gundersen, said recently on these matters: "After the Three Mile Island and Chernobyl accidents, followed by Fukushima it is rather safe to state that such accidents will never end... It is a nightmare that will follow us to the end of our life. Millions of people will become ill, and infinite number of people will slowly die".

What should ordinary Japanese do in such circumstances? It is unclear, why the public health system of Japan operates in the same poor manner as the USSR Public Health Ministry 25 years ago, after the Chernobyl disaster. Tokyo Shimbun newspaper reports that many children from Koriyama (50 km from Fukushima NPP site) complain about nose bleeding, diarrhoea, general weakness. Health providers attribute these symptoms to pollen allergy. At the same time, there are simple methods of radiation protection, as well as relevant practical experience.

For example, one may apply simple methods to reduce radiation body burden - I myself successfully applied them in 1986 (at that time I had internal radiation contamination 1 million times higher then the permissible norm, and I managed to reduce my body burden in 100 thousand times in 6 months):

1. Weekly visits to a steam bath (if general health status allows).

2. Iodine application on skin, timely made on one's back by a standard iodine solution (once in a week) will protect thyroid gland (the main accumulator of radioactive iodine) from consumption of iodine-131. As iodine-131 disappears in 70 days almost completely, now the latter precaution is not relevant any more.

3. One should consume potassium (chemical analogue of caesium). High potassium contents are found in pickled cucumbers (not marinated) and in sour cabbage. These products should be consumed every day. Potassium removes radioactive caesium from a human body.

4. Calcium is a chemical analogue of strontium. Consumption of products with high calcium contents can remove radioactive strontium from a human body and prevent its accumulation. To this end, large amounts of calcium-reach products should be consumed: raw green products (they should be carefully washed to remove dust), black

bread, cheese and parsley. Radioactive contaminants cannot deposit in a human body saturated with potassium, calcium and iodine.

But what is the most important - it is necessary to terminate radiation releases from damaged Fukushima reactors.

What should be done with damaged Fukushima reactor units?

Installation of the protective cover had been started at unit 1 of the damaged Fukushima-1 NPP. The cover construction is assembled by cranes from finished components that were pre-assembled earlier in neighbouring seaport of Ivaki.

Major Japanese construction companies Kodzima, Samidzu and Takenaka implement the cover construction. All components of the huge installation are reliably inserted into each other almost without threaded/wired connections. All these arrangements should accelerate the pace of works to the maximum extent possible.

The cover is expected to stop further releases of radioactive steam to the air and to prevent dissipation of radioactive dust from the Unit 1 building.

A ventilation system will be installed inside the cover, to prevent - among other things - accumulation of hydrogen that might cause new explosions. In addition, the ventilation system should reduce temperatures and humidity associated with continuous evaporation of water from the spent fuel pool.

The cover, assembled from synthetic shits on a metal frame, is 47 m x 42 m wide, with height of 54 m. The NPP operator - Tokyo Electric Power Company assures that the assembly will withstand earthquakes and strong typhoon winds.

They plan to complete the cover assembly works at Unit 1 by late September. I am absolutely sure that November is the earliest realistic deadline.

They plan to use similar constructions to cover Unit 3 and Unit 4 buildings, that were also half destroyed by hydrogen explosions.

The outer cover material is made from polyether-impregnated processed wood. The cover is quake-proof and - as its designers claim - can withstand 25 m/s winds.

Costs of these works are estimated at the level of about $1 billion. The NPP company operator (TEPCO) expects the covers to last for two years until all damaged reactor units will be covered by concrete enclosures. One may be a little bit puzzled to realise that Fukushima is expected to get three plastic cups for $1 billion ...

Initial cover parts at Fukushima seaport terminal

Conclusions (*to the second Russian edition*)

Less than 25 years after the Chernobyl, nuclear power had again delivered a new heavy blow to human health worldwide and to a national economy , this time in the technologically advanced Japan. Again, the losses were disproportionally higher than the lost income of reactor units disabled, nothing to say about the disease burden caused by nuclear reactors that exploded, not even speaking about consequences of radioactive contamination of land and sea, the very scale of which will take a long time to apprehend.

The Japanese had to protect their reactors but they deceived themselves, due to economic considerations. Critical reports of

Japanese media sources revealed that specialists of Tokyo Electric Power Co. simulated the worst tsunami scenario for their NPP site with application of their own corporate software instead of internationally recognised forecasting tools. Four months prior to March 11 they published a safety report that did not account for statistics on known maximal historical earthquakes, while their forecasts assumed the maximum height of tsunami waves at the level of only 18 feet (5.7 m). The actual height of the tsunami wave that hit Fukushima plant reached about 27 feet (8.2 m) - the wave flooded critical safety installations. TEPCO is also under criticism in connection with installation of emergency diesel generators in basements and ground floor rooms of the NPP buildings.

One may fall under the impression that nuclear specialists failed to learn anything from Chernobyl lessons. Even today they are not prepared to a major accident. Fukushima workers did not have individual dosimeters in sufficient supply. In the first days of the accident, to measure radiation doses they relied on instruments with the upper measurement limit of 1 Sv, that were absolutely inadequate to the actual situation.

Registration of internal radiation exposure was almost non-existent. As a result, people got excessive radiation doses due to failures to TEPCO top managers. Why does the company consider health of its personnel and local residents as a secondary priority? Why does the state ruled by bureaucrats rescues TEPCO instead of people?

Will TEPCO be punished? It seems unlikely. Notwithstanding that Moody's international rating agency reduced ratings of Tokyo Electric Power Co. (TEPCO) under investment or "junk" levels, the company will survive.

TEPCO's net losses in the last fiscal year (the one ended on March 31) reached ¥1.247 trillion ($15.28 billion) comparatively to its net income of ¥133.79 billion in the previous year. It is the largest loss in history of Japanese companies outside the finance sector. TEPCO shares lost more than 90% of their value. However, later the company shares grew by 32.12%. Analysts attribute such a sharp growth by decision of the Japanese Government to review a draft law on provision of state finance support to the company.

The company operator of Fukushima-1 NPP is expected to pay almost ¥4 trillion ($52. 6 billion) of compensations (ITAR TASS report referring to the independent commission that estimated damages caused by the accident).

The report's authors admitted that the estimate is not final, as it relied on standards set by the Government of Japan, that do not account for specific features of the contemporary situation.

In addition, the estimate does not account for costs of accident mitigation works, that are expected to exceed ¥20 trillion ($263 billion). The Government of Japan agreed to provide financial support to TEPCO in connection with repay of compensations, provided that the company will not set upper limits for eventual compensation payments.

To mobilise financial resources, the energy company started to sell some property and reduce its workforce. In addition, TEPCO plans to rise its electricity prices, but this decision might be blocked by the Government.

TEPCO intends to apply officially for government support in connection with the need to pay compensations to people who were evacuated from the exclusion zone. The Government will support the company notwithstanding its rather poor corporate record. Judge for yourselves - just one illustrative example [2011-09-29 13:03:00 source: *http://www.vesti.ru*]: "Japanese generating company Tokyo Electric Power Co. (TEPCO) - the company-operator of crippled Fukushima-1 NPP, in 10 recent years, overcharged Japanese consumers by more than ¥618 billion (about $8.5 billion). These facts are disclosed in the preliminary report of the Japanese state commission that conducted audit of the energy company that is now being blamed by many for the Japan nuclear crisis.

According to the audit's results, during 10 recent years TEPCO substantially inflated its generation costs. In addition, the difference between actual costs and costs reported by TEPCO is so high "that a possibility of error is absolutely excluded, suggesting that consumers were deliberately mislead".

The situation is associated with a mechanism allowing Japanese energy companies to shift some generation costs to consumers - i.e. charge higher electricity prices to ordinary citizens.

On Monday, October 3, another (non-governmental) commission will complete its audit of economic aspects of Fukushima-1 NPP operation in recent years. Should it confirm findings of the state commission, TEPCO would not avoid another major scandal".

Damaged reactors of Fukushima-1 NPP are damaged beyond repair, and their final decommissioning will require 30 years and ¥1 trillion ($12 billion.) - Bloomberg News Agency reported referring to Japanese officials and nuclear experts. I am sure that in a month they will claim a twice higher figure.

Yukio Edano, the Secretary General of the Cabinet of Ministers, admitted that the Government decided to close all nuclear reactors of the crippled NPP, including reactors # 5 and #6 that were not damaged by the earthquake and tsunami on March 11, 2011. According to Mr. Edano, experts are now considering different options to minimise adverse effects of radioactive contamination of areas around the NPP site. “We have not yet decided finally what measures will be necessary and efficient” - the official said. But it is absolutely clear that the third leading economy in the world might become a third world country.

Anyway, nuclear energy proponents continue to insist on positive future of their industry. “Concurrent growth of energy consumption, climate change concerns and fears of dependence on foreign supplies of fossil fuel stimulate development of nuclear power industry. Both rising gas prices and restrictions for coal use in connection with greenhouse emissions resulted in reintroduction of nuclear energy into the new electricity generation agenda in both Europe and North America”, the International Atomic Association states.

They are opposed by Walt Petersen, the oldest energy sector observer, a member of the Chatham House’s Program on Energy, Environment and Development: “Those who suffer from nuclear amnesia, have forgotten why nuclear energy disappeared from the energy arena in the first place. They have forgotten, how many times it failed to fulfil its electricity supply commitments, how often it frustrated its committed adherers, how eccentrically it wasted unparalleled, generous support from taxpayers worldwide, leaving them with a burden of radioactive waste that might persist for millennia”.

Chernobyl and Fukushima clearly demonstrate the real state of nuclear power industry - it is not dawn for it now, it is twilight. Let us stop misleading ourselves and start developing a really clean energy.

A few words about future of nuclear energy. In 58 years (the age of nuclear power industry) there were **four** off-design accidents: in the UK (Windscale-I) in 1957, in the US (TMI) in 1979 , in Ukraine (Chernobyl) in 1986 and in Japan (Fukushima-1) in 2011. Therefore, the actual probability of such an “inadmissible” event is 4/58 or 1/15. In other words, a disaster may happen with any reactor at average intervals of 15 years. What a future would wait for us at such frequency of off-design accidents. Only a radioactive one, unless we manage to think better.

Crafty scientists estimate probability of off-design accident in their own way and assess it as 1 event in 100,000 years. If we assume their point of view we will have to admit that an absolutely impossible thing has happened - we have already exhausted the limit for such accidents up to 400,000 years ahead.

In addition to Fukushima, there are other “potential Fukushimas” as well - NPPs that are highly prone to accidents due to the same reasons (outdated design, low seismic resilience, weak underlying soil under reactor units, poor tsunami protection). But owners of these NPPs are reluctant to invest money into their safety. We have to acknowledge that the Fukushima accident could have been prevented by means of extra costs of a few hundred thousand dollars. Yes, it was caused by a human error or, to be more precise, - due to lack of imagination. The Japanese had excellent technologies, but they failed to account for possible height of tsunami wave. It was enough to make the tsunami protection wall at the site a little higher. So, we may conclude that privately owned nuclear power industry is nothing but a weapon of mass destruction, and I am absolutely convinced that this is a plain truth.

Chapter 6. Accident is not over

In the course of preparing an English edition of the book, new information became available on the Fukushima NPP accident. The key conclusion - the accident is not over. It continues and even in early 2012 we cannot say that the reactors are safe.

Independent journalist Tomohiko Suzuki conducted his own investigation of the situation at Fukushima NPP (Dec. 18th, 2011 at 2:17 PM, *http://mdn.mainichi.jp/mdnnews/news/201 ... 2000c.html).* On December 15 he presented his findings at a press-conference. This 50 years old journalist managed to get employment as a worker of Toshiba Corporation and participated in the accident mitigation works for two weeks (from August 13 to 22) at the Fukushima NPP site.

Just a few facts: the journalist stated that 20-km exclusion zone around the NPP does not have a serious substantiation in terms of radiation safety. It should be extended to at least 80 km to the North -west, along the footprint of radioactive fallout . His conclusions are supported by recommendations of many experts and by the US Administration's advice to US nationals who are recommended to avoid staying closer than 80 km to the NPP site. The journalist suspects that the Government considers 80-km exclusion zone unacceptable as it would require evacuation of such major cities as Iwaki and Fukushima.

The situation at the NPP site is not much better. The majority of works there are merely a "show" for the general public. Toshiba and Hitachi corporations that work there do not share technical information, fearing data leaks to competitors. The media-cultivated image of joint efforts is nothing more that a myth, that is backed by the Government.

Many works at the NPP site are conducted in a hurry, in violation of prescribed terms, endangering safety of workers. The journalist quoted an anonymous manager of an accident-mitigation company - "Working at the Fukushima NPP equals to a death sentence".

Many workers try to manipulate data of their individual exposure dose meters, e.g. by hiding them in their socks to decrease registered exposure doses and get additional well-paid workhours at the NPP site. Some of them even deliberately leave dose meters when they go to the NPP site.

Managers of subcontractor companies rather often instruct their workers to fulfil tasks that simply cannot be accomplished in allocated time, also forcing workers to decrease their registered exposure doses.

According to the journalist, the daily radiation checks are reduced to a mere formality. As these checks are conducted too quickly, sensors simply cannot measure real changes of radiation intensity at clothes and radiation monitors often move sensors away from areas with elevated radiation intensity.

In the majority of cases, works around the NPP site are just of cosmetic nature, e.g. the repairs of the access road to the NPP. At the NPP site itself, due to lack of time and resources, many systems are not reliable. In particular, plastic pipes are used in the water treatment system, in cold weather the pipes might crack.

Engineers of Toshiba and Hitachi corporations proposed many new ideas, but they were rejected as unnecessary and redundant due to haste and lack of funds. As a result, reactors are controlled with application of minimal necessary means.

The journalist presented several shots made by a hidden camera and said in conclusion: “Many Japanese mass media outlets started to forget the disaster. But I think it is only beginning”.

In November, radioactive contaminants were registered in the US coastal waters. On November 1, traces of radioactive particles were registered at the distance of 3.5 thousand km to the East from Japan. The maximal level of radiation in some places that were examined by a Governmental agency specialists reached 5 Bq/l, while before the March accident, levels of radioactive particles in this area of the Pacific did bot exceed 0.001 Bq/l (see JAMSTEC map *http://fukushima.ucoz.ru/_nw/17/55018016.jpg).*

I think that the situation was predetermined. Transfer of nuclear power industry to private companies made it a weapon of mass destruction against the general population. Owners are greedy, and their greed does not allow them to ensure the due level of safety of reactor units and - in the case of major accidents - their greed force them to understate gravity of consequences. We observed all these manifestations in Fukushima. How has the state responded to the situation? The response was equally loathsome. The authorities managed to find tens of billion dollars to provide unprecedented finance support to TEPCO, but they failed to allocate funds to assist children who were exposed to radiation. *“According to Tatsuo Hirano, the Reconstruction Minister, the Japanese Government will not be able to provide free medical assistance to children - residents of Fukushima prefecture (Source: Jiji Press, January 28, 2012). When he arrived to Fukushima, he explained to Governor Yuhei Sato that the Government does not have sufficient financial resources to provide such privileges to children of districts affected by the nuclear accident. Governor Sato said that he deeply regrets Tokyo’s decision”.*

It is necessary to note that thousands of infants’ lives were lost due to the Fukushima NPP accident. December issue of the International Journal of Health Services (Washington, December 19, 2011, PR Newswire via COMTEX) admits that infants were affected particularly heavily. About 14,000 deaths in the USA were caused by the radioactive fallout from Fukushima reactors. It was the first such study published in a medical magazine and reviewed by medical specialists, that provided documented proof of adverse health impacts of Fukushima accident (Source: Joseph Mangano and Janette Sherman, International Journal of Health Services . Copyright © 2011 PR Newswire. All rights reserved. Electronic version is accessible at *http://www.radiation.org).*

The authors - Joseph Mangano and Janette Sherman - noted that the highest number of deaths was registered among American infants under 1 year. Only six days after the fuel meltdown in four nuclear reactors, on March 11, researchers registered poisonous fallout in the US coastal areas. EPA measurements, made a little bit later, allowed to identify radiation levels hundreds times above the norm in the air, precipitation and milk throughout the US. The highest iodine-131 levels in precipitation on the US territory (at norm of about 2 pCi per litre of water) were registered in: Boise, Idaho (130), Kansas City, Kansas (200), Jacksonville, Florida (150), Olympia, Wyoming (125) and Boston, Massachusetts (92).

Epidemiologist Joseph Mangano says "The study of adverse Fukushima impacts is the first such study published in a scientific magazine. It is alarming and requires further studies to understand real impacts of Fukushima on Japan and the whole world. The results are necessary for the on-going discussion on the need to construct new reactors and on terms of operation of those which are in operation". Specialist in internal diseases and toxicologist Janette Sherman says "Relying on our on-going research, we may suggest that the real number of death cases may reach 18,000…" The figure refers to the US only, and one may only wonder how many infants were "strangled" by Fukushima worldwide...

These facts induced radical changes in attitudes to Japanese power industry. In the course of the World Economic Forum in Davos, Greenpeace International conducted a contest for the title of the most irresponsible global company in 2011 - Public Eye. Tokyo Power Company - the company operator of the NPP that generated severe health and environmental impacts - was ranked second.

The Japanese Government responded adequately to the loss of public confidence in nuclear power and numerous protests. In his interview to "Asahi" on January 29, 2012, the Industry Minister Yukio Edano said that according to Government plans, all reactors will be put out of operation by summer. Edano also presented a program for transition to other energy sources, including solar power. It is a right decision, as Japan would not survive another Fukushima.

Now, 5 of 54 nuclear reactors are operational in Japan and I hope that they will really shut them down by this summer, and Japan will get rid of the threat of mortal impacts of the runaway "peaceful" atom.

Fukushima - one year after

The year has passed after the Fukushima NPP disaster and we can make some conclusions. They managed to install a temporary Sarcophagus over Unit 1 only.

All other equipment and the NPP site continue to release radioactive contaminants to the environment. In January 2012, radioactive releases even increased. Tokyo Electric Power Company admitted (Source: Jiji Press, January 23) that releases of radioactive substances from reactors of Fukushima NPP increased. In January, overall caesium emissions from units ##1 - 3 reactors reached 70 million Bq/hour comparatively to 12 million Bq/hour in December 2011. A month ago, measurements of radioactive emissions revealed releases of 10 million Bq/hour from Unit 1 and Unit 2 reactors, and 40 million Bq/hour from Unit 4 reactor.

On January 25, media reported thyroid-related problems of children who were examined in Fukushima prefecture after the March NPP accident. The medical examinations covered children from Namie, Itate and Kawamata. However, the below facts suggest that the authorities often conceal complete information and replace it by half-truth (Source: EX-SKF / Jiji Tsushin / Fukushima Minpo, January 25).

In particular, Japanese Information Agency Jiji Tsushin quoted representatives of the prefecture government: "From the overall figure of 3765 children under 18 examined, 26 children (0.7%) were found to have thyroid tumours with diameters over 5.1 mm". However, on the same day, city newspaper Fukushima Minpo provided a more detailed account of the situation: "From the overall figure of 3765 children under 18 examined, 26 children (0.7%) were found to have thyroid tumour-like indurations with diameters over 5.1 mm, while 1117 children (29.7%) were found to have indurations with diameters of 5.0 mm or lower".

Fukushima Gov. Yuhei Sato assessed results of the NPP works at the meeting with 3 members of the Cabinet of Ministers (Source: NHK, December 18). The meeting was held after the declaration of Japanese

PM Yoshihiko Noda (December 16) that they succeeded to reach the state of cold shutdown of all reactors and to contain the crisis. Governor Sato said that "he cannot believe that the crisis has been contained". Besides that, he called the Government to pay full compensations to every resident of Fukushima.

The Japanese had to review the program for mitigation of consequences of the accident that was approved in summer-2011 (Source: NHK, December 15, 2011). NHK got information on the program for the NPP dismounting developed by the Ministry of Industry and Tokyo Denryoku Company - the program relies on the earlier published report of the Japanese State Commission on Nuclear Power Industry. The new program incorporates a plan stipulating that spent fuel assemblies will be removed from cooling ponds of 4 NPP units for 2 years (starting from Unit 4). The plan stipulates that these works will be launched one year earlier than the State Commission required in its report. The removed fuel will be stored at the NPP site.

As for molten fuel assemblies in units ## 1, 2 1 and 3 reactors, their final removal will be completed in 25 years, after the launch of dismounting of reactors and unit buildings.

The Ministry and Tokyo Denryoku Company intend to complete dismounting of the NPP only in 40 years from now.

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