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NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF:

PUBLIC MEETING

BRIEFING BY OAK RIDGE ON "ANOTHER PERSPECTIVE OF THE 1958 SOVIET NUCLEAR ACCIDENT"

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CR4982

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

PUBLIC MEETING

BRIEFING BY OAK RIDGE ON "ANOTHER PERSPECTIVE OF THE 1958 SOVIET NUCLEAR ACCIDENT"

Room 1130
1717 H Street, N. W.
Washington, D. C.

Thursday, 24 May 1979

The Commission met, pursuant to notice, at 9:30 a.m.

BEFORE:

VICTOR GILINSKY, Commissioner (presiding.)

RICHARD T. KENNEDY, Commissioner

PETER A. BRADFORD, Commissioner

JOHN F. AHEARNE, Commissioner

ALSO PRESENT:

Messrs. Auerbach, Stoiber, Snyder, Gossick, and Dirks.

P R O C E E D I N G S

(9:50 a.m.)

COMMISSIONER GILINSKY (Presiding). I apologize for our late start here.

The briefing today will be presented by Mr. Auerbach of the Oak Ridge National Laboratory. He and other members of the laboratory published an article recently in "Nuclear Safety" magazine called "Another Perspective of the 1958 Soviet Nuclear Accident."

Nuclear safety, of course, is the subject, the business of this Commission, and we're very much interested in hearing what you have to say.

Mr. Auerbach?

COMMISSIONER AHEARNE: Before Mr. Auerbach starts, I had a couple of questions I wanted to ask him, sort of at least hit the framework for myself.

First, since this obviously relates to a perspective of an accident or a possible accident that occurred in a country where we have difficulty getting information, have you had access to classified material from either or any of the intelligence agencies regarding this?

DR. AUERBACH: With regard to this paper I'm discussing today?

COMMISSIONER AHEARNE: No, with regard to -- not the paper. We're, after all, not so much interested in the paper as we are in the events and analysis of events.

DR. AUERBACH: In the analysis of the events I'm talking about today, I have had access to the Freedom of Information Act material that the CIA made available to Mr. Kalish and other members of the group.

COMMISSIONER AHEARNE: But Mr. Auerbach, have you, so I can understand what you're going to be telling us, have you had access to the intelligence community regarding this event? If the answer is no, then my next question is, have you asked. And if the answer is yes, then I have a couple additional questions.

(Laughter.)

DR. AUERBACH: Well, Commissioner, that's a very, very difficult kind of question for me to address. I'm aware of the fact that there is a body of classified information.

COMMISSIONER AHEARNE: All right. Is what you're going to tell us today modified in any way by your understanding of that body of information?

DR. AUERBACH: No, sir.

COMMISSIONER AHEARNE: Do you think it would be useful for us to, as a Commission, in another forum, have access --

COMMISSIONER GILINSKY: I wonder if you'd handle that at the end of the meeting?

COMMISSIONER AHEARNE: Well, Victor, I had asked this question prior to this meeting being called. So I thought I'd try to get an answer.

DR. AUERBACH: That's not a judgment I can make, Commissioner.

COMMISSIONER AHEARNE: You're not sure whether it would be useful to us or not?

DR. AUERBACH: I'm not sure what your internal problems are with respect to these matters.

COMMISSIONER AHEARNE: Assuming that the question is, do you think that information might be useful --

COMMISSIONER KENNEDY: Doctor, I wonder if we could go ahead.

COMMISSIONER GILINSKY: I would like to hear.

DR. AUERBACH: If I may have the first slide.

(Slide.)

About a year and a half ago, Dr. Zhores Medvedev came to the Oak Ridge National Laboratory, specifically to see us, since we have a major radioecology group, and to interest us in exploring and relooking at the question of the so-called Soviet nuclear accident that he had written about in somewhat dramatic form in "New Scientist."

We spent two days with him and he stimulated us to start looking at it in the context of the way he had looked at it, only in greater detail, in bringing to bear our own particular special expertise.

The next slide.

(Slide.)

In doing so, we, like he, relied on three kinds of information sources. The first was to go back and look at what was available in accounts by former Soviet citizens. Secondly, we received the CIA public information that was released to the public under the Freedom of Information Act. Third, we began to review, following his sort of lead, the Soviet scientific publications in ecology, to start looking for the clues that he alluded to in his article "New Scientist."

The next slide.

(Slide.)

The sequence of events on this thing, just to bring it back, is that he wrote his first article on Soviet dissidence in November of '76, wherein he mentioned this accident almost in passing. He dealt also with the well-known or presumably well-known accident at the Soviet Cosmodrome, where it killed the cosmonaut.

He immediately got back a response from Sir John Hill which called his talk science fiction. Dr. Lev Tumerman then reported on his trip -- I'll have a little more to say about that -- and then Medvedev came out with a larger article in "New Scientist" on the nuclear disaster, in which he provided his rationale and his evidence for the fact that he felt such an incident had taken place.

May I have the next slide.

(Slide.)

The area that was identified and has since been identified also in the CIA material is in Cheliabinsk province. In the CIA material, mention is made of a military nuclear installation near the community of Kasli, although in the material also, information is also stated about a nuclear facility near the city of Kyshtym.

In these materials, talk of various kinds of accidents are given with particular impact on the citizens in this city of Kamensk-Ural'skii.

Dr. Tumerman, whom I went to interview in Israel while I was there in September, reiterated to me his particular observations. He, curiously enough, had been meeting here, in the Cheliabinsk nature reserve, in a clandestine meeting of biologists who were anti-Lysenkoists and were meeting in 1961 in this secret sort of national forest.

Right after the meeting was over they offered to drive him back to Sverdlovsk to catch a plane, rather than go back here and go by train. So he drove this road and, as he said to me, when he got to about 100 kilometers south of Sverdlovsk, he saw some signs. He stopped a driver. He noticed houses deserted, some without any chimneys. He wanted to take a drink of water; he was told the area was polluted with radiocontamination and they had to move.

You'll note this is an area with lots of little reservoirs, with this river, the Techa River, crossing the area; and again, which this information document speaks of being heavily contaminated and monitored, and citizens were forbidden to fish and get food out of it.

The next slide.

(Slide.)

To give you some perspective on the population density, I think it's pertinent to the general interest: three cities in 1939, '59, '67, and 1978. And as you can see, in terms of population growth and density, whatever took place there, if it took place, seems to have had no impact on the growth of those communities, Cheliabinsk in particular. Kamensk-Ural'skii, the smaller city, didn't have any data for 1978. Sverdlovsk, the major city.

If I may have the next slide.

(Slide.)

To give you some perspective of the province in comparison to an area of the United States -- we have done this previously -- we compared Cheliabinsk province with the state of Tennessee, which is where we come from. Both have a population -- in the year 1959, Cheliabinsk had a population of 3 million, Tennessee had 3.9. Population densities are very close and the land area is very close.

Both are provinces or states that are somewhat isolated or were somewhat isolated. There are heavy rural country with forests. The land under cultivation, as you see, is about 32 percent in Cheliabinsk. That's about the same as it is in Tennessee.

In 1945, Tennessee had a secret unknown nuclear installation also, at the time.

There are some interesting similarities.

The next slide.

(Slide.)

Just background. The climate of Sverdlovsk, however, is quite different -- I'm sorry, of Cheliabinsk province -- is quite different than that of Tennessee. It's a cold area. The mean annual temperature is quite low, particularly for Sverdlovsk. The mean January temperatures are low; lots of snow; cold, inhospitable area.

Now, the thing that we started to do, following our meetings with Medvedev, was to start looking at the Soviet radioecology literature and exploring it, reading it, exploring it, analyzing it in detail, to pick up the kinds of clues that he had said were there, that either were there through clever bypassing of the censorship or the censorship, if it was present, simply was insensitive to certain details.

Likewise, we also examined the Soviet literature to try and confirm certain other points that he made.

If I may have the next slide.

(Slide.)

Now, among the things that we saw, of course, was the fact that there was consistent mention of contamination by strontium 90 in particular, that were simply too high in terms of what our experience had been in doing field work in radioecology to have been done experimentally.

As I indicated there in the second comment, the activity levels ranged up to 3.4 millicuries per square meter. This is a level that is almost at the point of producing radiotoxicity when you start to calculate dosage.

COMMISSIONER GILINSKY: When you say too high to be something that would be done in the normal course of experimentation, you mean?

DR. AUERBACH: Going out and deliberately placing the material there, that's right.

Furthermore, the areas that are described, for example, one plot os 100 by 100 meters. Now that's a squared football field, and that is contaminated to those levels.

The pattern of contamination, however, is not uniform, and it would appear to us, therefore, to have been unlikely to have been applied deliberately, assuming one knew how to apply strontium 90 in such quantities over such a large area.

Furthermore, when we looked at the Russian papers and reviewed them, we found that, as Medvedev did, that they were talking about collecting deer -- and I'll come back to things about water in a minute -- deer and other mammals that were contaminated, and were following their uptake and their movement.

Now, to support such populations you need a certain land size. For example, 21 deer can't be collected over a small area. The deer have large ranges, and if you're assuming that the deer, the 21 deer, are merely a subset of a larger population occupying an area, you are dealing with a fairly large zone.

The water bodies, of which three were consistently identified in works produced in the 1960s, ranged from four and a half kilometers square up to somewhere around 20 square kilometers in size. Each of these, based on the literature, contained sufficient radionuclides --

COMMISSIONER KENNEDY: How much of this literature is there?

DR. AUERBACH: There is at least 115 articles. And the literature actually identifies the water bodies and their size.

If I may have the next slide.

(Slide.)

Now, there is an unusual consistency in the articles on the isotopic ratios. The terrestrial studies, which weren't really reported 'til somewhere in the mid-60s --

meaning you had somewhere between 9 and 12 years decay time, between presumably when the material was applied in some form -- it was done by an accidental mode. We note there that the ratios of strontium 90 to cesium 137 are over 100 to one.

In the aquatic studies, wherein they got in a little earlier, a report getting in earlier, they talked of cerium 144 to strontium 90 to ruthenium 106, to a ratio of 10:1:1, with no indication of cesium 137 at time zero. Those ratios in the aquatic, we believe, technically would preclude that material coming from a long-lived waste disposal facility undergoing some kind of venting, which is what Medvedev said he thought happened in his article. And a long-lived waste facility would not have those ratios.

I'll also mention the other ratio that is unique and is the most difficult one to reconcile, is this ratio of strontium 90 to cesium of over 100 to one. The reason for that, gentlemen, is that in every normal fission event that takes place the ratio of strontium 90 to cesium is always unity, one to one. For every atom of cesium 137 produced in a fission, there is one atom of strontium 90. And this poses -- these ratios appear continuously in every Russian article. Our only assumption is that, one, there was consistent censorship that did something to alter the ratios, which is a little hard to believe; there was a simple repetition of the same number, as sometimes happens in journals. They're given a number and they use it. That may be a reason. Or, three, there's a technological reason -- and I'll get to that -- why there is this ratio.

If I may have the next slide.

COMMISSIONER GILINSKY: Are these articles all dealing with the effect of these radionuclides on plants?

DR. AUERBACH: Or their transport, movement through the food chain, that's right.

COMMISSIONER KENNEDY: Is there any indication of why all 115 articles we're talking about, dealing with essentially the same area, physical area?

DR. AUERBACH: That's right.

COMMISSIONER KENNEDY: Is there any indication why, in all these articles, why the area was siezed upon? What generated the articles in the first instance?

DR. AUERBACH: According to Mr. Medvedev, his premise is that there was a major nuclear accident in the province.

COMMISSIONER KENNEDY: I realize that.

DR. AUERBACH: And that, as a result of that accident, plus internal Russian politics in science at the time, plus the pressures of the Russian radiobiologists, there was a massive movement of scientific groups into that area to take advantage of this unique study site that had been created for them. That's the reason. That's why we see that time lag between, assuming that you had an incident in '58 -- you

531 259

wouldn't see papers for three, four or five years.

COMMISSIONER AHEARNE: I think what you're saying is that in the articles themselves, they don't start out with any explanation as to why?

DR. AUERBACH: No. All they talk about is an area experimentally contaminated or an area receiving a single treatment.

COMMISSIONER AHEARNE: And then go on to list them?

COMMISSIONER GILINSKY: These presumably are scattered over many journals?

DR. AUERBACH: Over many journals throughout the Russian literature and over a period of ten years.

COMMISSIONER AHEARNE: Can I ask you a question on your previous chart? You don't have to go back to it. You had mentioned the ratios, that that would preclude coming from a long-lived waste facility. Do you mean that it would preclude coming from a facility that has been operating for any length of time?

DR. AUERBACH: Yes, five to ten years.

COMMISSIONER AHEARNE: Would it be possible to come from a facility that had just started operation?

DR. AUERBACH: If you can account for the peculiar cesium difference. I want to just come back to that, if you'll let me. I'm going to come to t.

COMMISSIONER AHEARNE: Okay.

(Slide.)

DR. AUERBACH: Now, when you analyze all the areas, when you analyze all the literature in terms of the flora and fauna, and then you compare that against Russian biogeographical material, it all falls into this one area. This is the only area in Russia that has this particular combination of tree species, lakes, soils, that are identified in this mixture of articles. The site is a likely one.

COMMISSIONER AHEARNE: In all these 115 articles, did they specifically identify this region?

DR. AUERBACH: No. They don't identify the region at all, except one Vincent Cheliabinsk Province.

COMMISSIONER AHEARNE: I see. So you have deduced.

DR. AUERBACH: We deduced from looking at the species list the names of the organisms and the soil types; the description of the reservoirs and their sizes deduces as to where it is.

COMMISSIONER AHEARNE: The 115 articles, does that represent a sizeable portion of the overall body of literature on the subject in the Russian literature, or a small fraction of it?

DR. AUERBACH: I am not sure, Commissioner. I guess the answer is: I am not sure at all. I would say that it probably represents maybe 25 percent because somewhere in the '60s or '70s the whole area of environmental studies in Russia

531 261

in the mid-'60s got much larger, and work got started in many other areas. It's a growing literature.

If I may have the next slide -- this is it. Leave that one back on.

Il'enko's Lake. This is one that Mr. Medvedev made an important claim about, which gave us a great deal of concern. Studies were conducted by this scientist in '69 and '70, and he reported again this ratio of almost one to 100, one to 10 in this one, in the lake, of strontium-90 to cesium. He spoke of this lake based on the numbers as its having received strontium-90 from the entire surrounding area, drained into the lake. His estimate was 10-9 curies of strontium-90 in the lake. One billion curies.

Well, we couldn't come up with that type of number. For one, in looking at it, we found that the lake was an open-drain lake; it wasn't a closed system. So that there was a wide fluctuation in the radioactivity content. It is a large lake, because they collected about one-quarter metric ton of pike, including three pike in the three- to 10-kilogram class. Those of you who are fishermen, you don't get pike that size except in a large lake.

And in looking at the data, we estimated that the lake contained between 10-5 and 10-6 curies of strontium-90, about a thousand-fold less than Medvedev. His ass

His assumption was that it drained from the entire drainage basin into the lake and that all these hundreds of thousands of curies sort of migrated in.

Well, that's where his nontechnical background in that area, I think, led him astray. You wouldn't get even over a period of 10 years the movement of all of the isotopes in the drainage basin into the lake. And, as a result, that was another area which we think he overestimated the magnitude of the materials, and perhaps the land mass, contaminated.

COMMISSIONER AHEARNE: So I can understand, you're saying that Il'enko did not --

DR. AUERBACH: Not Il'enko. Medvedev.

COMMISSIONER AHEARNE: Il'enko did not estimate the 10-9; it was Medvedev.

DR. AUERBACH: Medvedev.

COMMISSIONER AHEARNE: Did Il'enko make any estimates?

DR. AUERBACH: No. He was giving a paper on the mathematical transport of isotopes between sediments and water, and he talked of this lake that had received a contamination.

COMMISSIONER AHEARNE: But his paper gave the .2 microcuries per liter?

DR. AUERBACH: Yes.

COMMISSIONER AHEARNE: Now, you're saying that Medvedev here was assuming that everything drained into the lake.

DR. AUERBACH: That the lake was closed.

COMMISSIONER AHEARNE: Could you follow through, then, if the lake is open and everything doesn't drain in --

DR. AUERBACH: It's two different things. If the lake is open, it's also losing material, as well.

COMMISSIONER AHEARNE: Right. So that then wouldn't the measured content in the lake be less than if it were closed and everything drained in?

DR. AUERBACH: That's right.

COMMISSIONER AHEARNE: So you're saying that Medvedev nevertheless, while assuming something would have led to an estimate of a lesser total in the area because nothing's lost and it's all collected, still ended up with a thousand times higher?

DR. AUERBACH: No, he didn't calculate it. We disagreed with his -- our assumption is that it didn't all drain into the lake; it wouldn't.

COMMISSIONER KENNEDY: And that it was an open system. He said it was a closed system.

DR. AUERBACH: He assumed it was a closed system.

COMMISSIONER AHEARNE: What I am having trouble with: Here you have this lake, and you're both starting with the same measurement of what's in the lake.

DR. AUERBACH: Right.

COMMISSIONER AHEARNE: If it is a closed system and it all drains in, then it would seem to me that the total amount that's on the outside is going to be less than if it's an open system and not all drains in.

DR. AUERBACH: On the outside, that's right. But we don't know. He came up with a large number.

COMMISSIONER KENNEDY: In the lake.

DR. AUERBACH: In the lake. And he assumed it came from the outside. We don't think that's a tenable technical position.

COMMISSIONER BRADFORD: Do you disagree with the large number?

DR. AUERBACH: We disagree with the large number, because to have 10-9 curies of strontium-90, that's more than we have in the Hanford waste tanks now after -- what is it -- 20, 25 years of military processing. In other words, the number of reactor-years of operation necessary to produce one billion curies of strontium-90 in 1957 or 1958, we don't think existed in the Soviet Union; there weren't enough reactors operating.

Now, this lake is in --

COMMISSIONER BRADFORD: Is it a difficult calculation, though, to get from the microcuries per liter to some estimate of how much is in the lake?

DR. AUERBACH: No, it's relatively easy. That's how we came up with the 10-5, 10-6.

Next slide.

(Slide.)

Well, I guess the critical question, after looking at this and, we'll say, convincing ourselves what could have been the potential accident mechanism involving reprocessed wastes --

COMMISSIONER GILINSKY: Getting back to this lake, what significance do you attach to those numbers?

DR. AUERBACH: In what sense?

COMMISSIONER AHEARNE: Even the two-tenths.

COMMISSIONER GILINSKY: Even your lower numbers.

DR. AUERBACH: The significance only, again, is the disparity in the strontium-cesium ratio. It raises also the question that the lake could have been contaminated through another mechanism. It could have been chronically contaminated. It [illegible] part of the network of reservoirs that are in this area, and it could have received its contamination through chronic poor practices, which could account for why it's also a little difficult to deal with in terms of the numbers.

COMMISSIONER AHEARNE: When you're estimating what the total strontinum content is or the total curies, do you assume that the .2 microcuries per liter is an accurate measurement?

DR. AUERBACH: No, but it's the only measurement we've got to go on.

COMMISSIONER AHEARNE: But in getting to your million?

DR. AUERBACH: Yes, we have to assume that. That's the only number we have to go with. It's like the strontium-cesium ratio; we have no other source.

COMMISSIONER BRADFORD: If that number were the result of poor practice, though, then wouldn't it be some fraction, perhaps larger, but still a fraction of the total number of curies available? That is, it would be more than poor practice to lose them all.

DR. AUERBACH: I am not saying you'd be losing. When you say "lose them all" --

COMMISSIONER BRADFORD: By "poor practice," you're saying what?

DR. AUERBACH: That they used the lake as a recipient for some of their waste effluent stream.

COMMISSIONER KENNEDY: Or used several of the reservoirs in that area.

DR. AUERBACH: In that area, which drained there.

COMMISSIONER BRADFORD: And just simply directly discharged all the radioactivity?

DR. AUERBACH: That's right. We have no way -- I can't verify that, but it's something that's not implausible.

COMMISSIONER GILINSKY: How do these numbers compare with permissible limits for concentrations?

DR. AUERBACH: Much, much higher.

COMMISSIONER GILINSKY: By factors of how much? Than what is permissible?

DR. AUERBACH: I am trying to recollect here. I think, in some cases, it's comparable to fallout levels, which,

531 267

of course, are also lower, but they're thousands of times higher than the fallout. Then they must be hundreds of times, if not thousands of times, higher. In the case of strontium-90, it's thousands of times higher than our permissible limits for strontium-90. It's an incredibly high number.

COMMISSIONER AHEARNE: What about for water?

DR. AUERBACH: Here they're talking about tenths of microcuries, and I don't remember what our current level is. It's 100 picocuries, which is 10-6, 10-6 smaller than that. So you're down to 100,000 times the limit.

Well, the mechanisms that we tried to postulate, and without trying to put any kinds of probabilities on them, but just plausibilities: One you might have had, there might have been a nuclear criticality incident that took place in conjunction with waste processing. Remember, we were back at a time when the Russians were presumably striving to catch up with us rapidly. Again, based on Medvedev's article, Russian sensitivity to radiation protection didn't seem to begin until 1960. He, of course, attributes that to whatever took place here.

Waste processing was slow, primitive. There is the possibility of a conventional explosion or fire, resulting either from the use of solvents; ethers, and ether-type materials were used in early waste-processing techniques.

COMMISSIONER AHEARNE: But this is still an explosion or fire in a waste facility?

DR. AUERBACH: Some kind of waste facility. It could have had -- there was a process that used nitric acid, and you used the combination of nitrate wastes with solvent residues that might result in an explosion. One process made use of ammonium nitrate. Ammonium nitrate, as you know, is a highly explosive material.

We had one sad incident in the United States, you remember, in Texas City in 1947. The Canadians had an incident at Chalk River.

Or, in a waste tank, you could have had a radiolytic production of hydrogen with a hydrogen-oxygen mixture. And that could produce an explosive combination.

COMMISSIONER KENNEDY: All of these assumptions relate to waste processing?

COMMISSIONER AHEARNE: Which you had said earlier, the ratio.

DR. AUERBACH: Okay, now, let's come up to the cesium-removal mechanism.

Next slide.

(Slide.)

To us, there are two plausible mechanisms for the removal of cesium. One is somewhere in the processing it goes to a high-temperature phase, and cesium becomes volatile at 400 degrees centigrade. And, for some reason, the cesium was volatilized and removed from the materials going to waste storage. That's one possibility.

Another possibility was: About that time, the Russians were very much interested in the relevance of the use of gamma isotopes for sterilization of foodstuffs. The sterilization of meat and potatoes. In at least one instance, there is a Russian publication which talks of using huge quantities of cesium 137 to make radiation sources for food irradiation. And so one might conjecture that they removed lots of cesium and processed it right away to make sources for their food irradiant.

Those are the only two mechanisms that we can come up with, in a technical sense, to account for the no presence of cesium.

COMMISSIONER AHEARNE: How about the ratios, though of what you're talking about?

DR. AUERBACH: That's the only way we can explain the ratios.

COMMISSIONER AHEARNE: Even putting aside the cesium, you had pointed out that it would certainly preclude --

DR. AUERBACH: Long-lived wastes. But not short-lived wastes. Wastes a year or two old.

COMMISSIONER AHEARNE: It's a short-lived waste. And then, with the cesium removed --

DR. AUERBACH: It would account for the pattern of distribution. Now, that, of course, also tends to preclude a reactor-type incident where you have fission materials spewed out. Then you get the strontium-cesium.

COMMISSIONER AHEARNE: So, in other words, the only explanation you can think of is some deliberate removal mechanism?

DR. AUERBACH: Of the cesium, or a process that volatilized it at some point and just removed it and handled it separately.

COMMISSIONER AHEARNE: When you say "a process," you don't mean in the midst of an accident?

DR. AUERBACH: No.

COMMISSIONER AHEARNE: Again, it would be a deliberate removal.

DR. AUERBACH: Deliberate removal.

COMMISSIONER KENNEDY: With some kind of accident occurring after that?

DR. AUERBACH: That's right.

COMMISSIONER KENNEDY: Not in the process of doing it?

DR. AUERBACH: I don't think so.

COMMISSIONER AHEARNE: Because you'd still have some cesium.

DR. AUERBACH: Next slide.

(Slide.)

From this conclusion, the conclusion to this paper, we're talking about this paper primarily, although I broadened my comments somewhat, is that, one, that an exhaustive analysis of the Soviet literature is warranted.

COMMISSIONER AHEARNE: You mean more exhaustive than you've done; is that what you mean?

DR. AUERBACH: More exhaustive than we did for this paper. We have since done a more exhaustive analysis of it.

Medvedev's conclusions about the source and extent of the contamination zone may be untenable. The evidence exists for a fair-sized area, greater than 25 square kilometers, accidently contaminated with high levels of radioactivity. By "high levels," we mean approximately or greater than one millicurie per square meter of strontium-90.

COMMISSIONER GILINSKY: How large an area was he talking about?

DR. AUERBACH: He was talking about thousands of square miles.

The best explanation presently seems to involve accident, although a chronic water-borne release cannot be ruled out. And the reported isotopic ratios, if accurate, rule out a nuclear explosive or reactor accident as the source.

COMMISSIONER AHEARNE: By "chronic water-borne release," doyou mean continual dumping?

DR. AUERBACH: That's right. They had an operating facility there which was continuously releasing material.

The dominance of cerium 144 at the start of one aquatic study suggests that fission products were one to two years old when released.

The isotopic ratios in the terrestrial studies indicate that an intervening cesium-removal mechanism was involved.

The combined information suggests that the explanations involving release from a radiochemical separations high-level waste storage facility are presently most credible to us.

Just one last slide would be more informative.

(Slide.)

This is, again, to bring you or remind you of the rations of fission product waste activities to cesium 137. This is just fundamental nuclear physics. After so many days of decay, you see the ratio of strontium to cesium is always one, all the way through five years or more.

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531 273

COMMISSIONER GILINSKY: Why would they want to take the cesium out early in the process?

DR. AUERBACH: There is no explanation, sir, other than the one that they wanted to use or create large-scale cesium irradiators for grain. That would be the only reason to take them out, unless you had some other kind of storage.

COMMISSIONER KENNEDY: Is there evidence that they ever did something on that order? Was there a program?

DR. AUERBACH: There was a program.

COMMISSIONER KENNEDY: Is there any evidence that there was a focus of that program on the strontium?

COMMISSIONER AHEARNE: You said that in your answer, you said, to this paper. Then you went on and mentioned that you have done a more extensive sort of analysis.

Do you have any modifications to your conclusions based on that more extensive study?

DR. AUERBACH: No. They are more confirmatory. They leave us feeling convinced that there was a major incident in the region.

COMMISSIONER KENNEDY: Your paper said the most credible case does appear to involve some sort of accidental airborne release. But you're not ruling out the water-borne release?

DR. AUERBACH: No.

COMMISSIONER KENNEDY: But you think the airborne release is much more credible?

DR. AUERBACH: I think what I'm really saying, what I'm really trying to say, Commissioner, is that all the evidence suggests that here was a major nuclear facility and running under some head of steam. It is not inconceivable that they were both chronically contaminated --They may have had one accident, they may have had two accidents. We don't know. But it would suggest that they contaminated a large area.

COMMISSIONER AHEARNE: Why do you say two?

DR. AUERBACH: Why do I say two?

COMMISSIONER AHEARNE: Maybe it would be three? It may be four?

DR. AUERBACH: We have no way of arriving at that. We look at these mixed reports. We can identify, at least we think, the two, the terrestrial area and the water area.

COMMISSIONER AHEARNE: Now, there is this really unique feature of no cesium, and you mention that that appears to have been part of the technological -- at least your best conclusion is that that was a deliberate removal mechanism?

DR. AUERBACH: Assuming that we have not had a consistent literature error put in over that period of time.

COMMISSIONER AHEARNE: Is there anything that would lead you to believe, or can you answer whether or not, any mechanism that you know of to do that cesium release might or might not, then, have made an accident more or less likely?

531 275

DR. AUERBACH: I would be technically unable to do that.

COMMISSIONER AHEARNE: Now, Medvedev, I gather, had drawn the conclusion that the Soviet emphasis upon radiation protection, et cetera, was a result of this?

DR. AUERBACH: That's right.

COMMISSIONER AHEARNE: And that prior to that --

DR. AUERBACH: There was very little, or, as he puts it, the radiation geneticists and radiation biologists had no influence with the Khrushchev government because of Lysenko, and they were unable to convince them. The physicists were the truly elitist groups in the Soviet Union in getting what they saw as problems arising and getting them under control.

This accident, to use an Americanism, scared the bejabers out of the rest of them and got the others to see the light.

COMMISSIONER KENNEDY: Has there ever been in this literature reference to human contamination?

DR. AUERBACH: Medvedev alludes to it. We have not looked at literature or looked for literature that deals with humans.

COMMISSIONER AHEARNE: Now I want to finish asking the question. The question was: Did you find it useful to have discussions with the intelligence agencies?

DR. AUERBACH: I think discussions with any group that may have had some information is always useful.

COMMISSIONER AHEARNE: Is always useful.

COMMISSIONER BRADFORD: When you say you haven't looked for information pertaining to human contamination, why would that be?

DR. AUERBACH: Well, primarily because our group isn't qualified in that area. We focus strictly on the environmental-ecological system. We think that it should be looked at by somebody. It takes a fair amount of skill, because you've got to get -- a good portion of the literature is in Russian. You've got to then get it translated, and you've got to have somebody who knows Russian also looking over it, to make sure that the translator is not losing nuances, even as much as punctuation at times.

And so, it would take some people with a medical-biological background, and also with a pretty good Russian background, I think, to dig for that and start looking. It's really looking for clues, is all you're looking for.

COMMISSIONER BRADFORD: Wouldn't it be a useful indicator, for example, of whether or not this had been a continuing dumping into the water or an airborne release?

DR. AUERBACH: I think also, it just would be of value, assuming one could get it, to ascertain in another way whether or not something took place there and did it affect the human population.

Now, the allegations are that there were huge numbers of casualties.

COMMISSIONER AHEARNE: That's Medvedev.

DR. AUERBACH: That's Medvedev. And the Freedom of Information materials talk a little about that as well. If in fact it was so, it would be presumably an important set of scientific facts for people to know about.

COMMISSIONER AHEARNE: In trying to do the analysis of the waste theories, have you discussed with the United States, the Energy people, the Department people that handle waste disposal?

DR. AUERBACH: Yes, we have consulted with waste people, technical people, in our own laboratory, and we've also had the benefit of input from waste management people in a number of the other major facilities.

COMMISSIONER AHEARNE: How about Hanford?

DR. AUERBACH: I said the other DOE labs, including Hanford, Savannah River.

COMMISSIONER AHEARNE: Is it a fair conclusion that, in addition to your getting input from them, that you've also discussed this with them?

DR. AUERBACH: We have discussed the mechanisms and the incident with some of the key people at these labs.

COMMISSIONER AHEARNE: Two of them, so that this is not -- this information is not today new to them?

DR. AUERBACH: No, to some. I don't know about all.

COMMISSIONER GILINSKY: Of course, it's been published.

DR. AUERBACH: In "Nuclear Safety," which is, of course, reviewed also internally by your staff and by the DOE staff.

COMMISSIONER GILINSKY: I should have mentioned at the outset that Dr. Auerbach is the director of the Environmental Sciences Division at Oak Ridge.

Anything else?

(No response.)

COMMISSIONER GILINSKY: Thank you for a very interesting presentation.

COMMISSIONER AHEARNE: Is the secretary here? Or perhaps, Victor or John Hoyle? I had requested at the time when this came up that we also receive information from the intelligence agencies on this. Has this also been set up?

MR. CHILK: We're trying to get that set up. At the time we were having difficulty getting both briefings put on at the same time. In discussion with the Commissioners, the majority of the Commission indicated that they wanted a briefing quickly. And a briefing is being set up.

COMMISSIONER AHEARNE: Fine. Thank you.

COMMISSIONER GILINSKY That ends that portion of our meeting today.

(Whereupon, at 10:40 p.m., the meeting was adjourned.)

Operating Experiences

POOR ORIGINAL

Edited by William R. Casto

Another Perspective of the 1958 Soviet Nuclear Accident

By J. R. Trabalka,* L. D. Eyman,* F. L. Parker,* E. G. Struxness,* S. I. Auerbach*

Abstract: *The occurrence of a major Soviet nuclear accident involving stored, reprocessed, long-lived fission wastes has been reported by former Soviet citizens. Z. A. Medvedev, writing in the popular science magazine* New Scientist, *believed that the accident resulted in significant loss of life and required the permanent evacuation of the civilian population from a large area (several thousand square miles). Although Medvedev appears to have reached untenable conclusions about the exact origin and extent of the contaminated area, it does appear that a credible case can be made for an accidental airborne release of fission wastes in the general geographic location he suggested. In view of the growing importance of nuclear power as a world energy source, an exhaustive critical review of the Soviet literature is warranted to resolve doubts about the exact nature and consequences, indeed even the occurrence, of the postulated accident.*

Retrospective accounts by former Soviet citizens[1-4] have indicated the presence of an extensive, uninhabited area contaminated by radioactive materials in Cheliabinsk Province (in the Ural Mountains) of the USSR. Two independent sources (Medvedev[1,2,4] and L. Tumerman[3]) have indicated that the highly radioactive restricted area, which lies between the cities of Cheliabinsk and Sverdlovsk, was established after an explosion at a storage site for long-lived high-level military nuclear waste during the winter of 1957–1958. They both believe, on the basis of information supplied to them from a variety of sources, that the accident resulted in a significant loss of life (hundreds of people) and required the permanent evacuation of the civilian population from a large area.

Extensively edited and unevaluated information released from the files of the U. S. Central Intelligence Agency (CIA) to a citizens' group[5] indicated the presence of military nuclear facilities near the city of Kasli (Fig. 1). Although the accident has been designated in various reports[2-6] as the "Kyshtym Disaster," the choice of the name appears to be associated with the largest city near the accident site. The actual facilities reported were located northeast of Kyshtym.[5] The city of Kasli may be a more suitable reference point for the actual location (Techa, Sungul) of the nuclear facilities described in the CIA documents. These facilities were located among many large lakes in the upper Techa River drainage. The Techa River itself reportedly[5] has been contaminated with radioactivity throughout its course. The CIA documents[5] indicate the occurrence of a nuclear-related incident (or incidents) and subsequent high-level radioactive contamination in this area between 1956 and 1961, most probably during the winter of 1957–1958. No cause was clearly identified; the possibilities suggested were either an explosion in a high-level-waste storage area or an experimental airborne nuclear weapons test. The scope of the accident, in human terms, was not well-defined but appeared to involve

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531 280

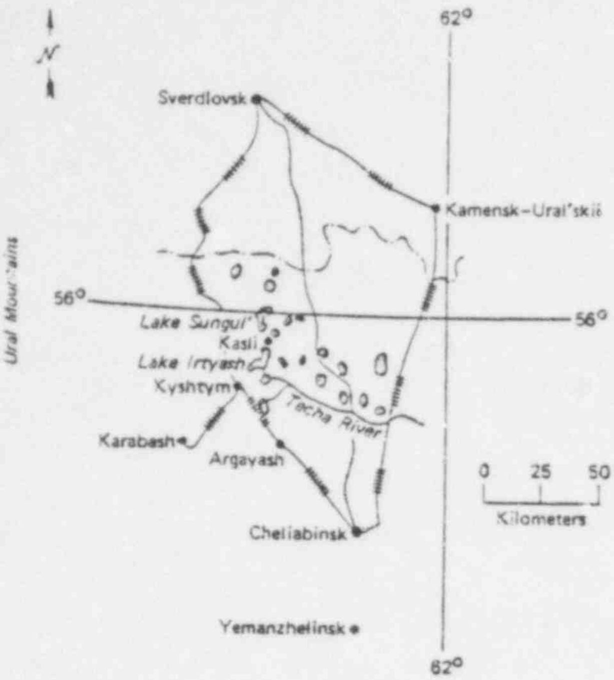

Fig. 1 Geographic region in which major Soviet nuclear accident reportedly occurred. ——, railroad; ——, road or (where named) river; ———, boundary between Sverdlovsk and Cheliabinsk provinces.

some loss of life (magnitude undetermined), evacuation of the civilian population from a large area, and establishment of a restricted, radiation contamination zone near the Kasli site.[5]

The CIA documents appear to corroborate some important aspects of the conclusions drawn by former Soviet citizens. However, any objective observer must also conclude that there are significant inconsistent elements present in these two separate sets of information. For example, two CIA reports, based on interviews conducted in November 1961, are questionable in terms of their relationship to the Kasli incident (our nomenclature). Internal inconsistencies about dates in the two reports, coupled with the location of alleged radioactive fallout (130 km south of Kasli), raise serious doubts about their validity or that they refer to the same event. A disturbing feature of both sets of information (from the CIA and from the Soviet citizens) is the notable absence of either first- or second-hand accounts of the incident itself or confirmed authoritative information related to its aftermath. The absence of first-hand information originally led Medvedev to conclude in his original report[1] that the accident occurred near the city of Blagoveshensk (over 300 km west of Kasli). From his literature search and Tumerman's subsequent account, Medvedev concluded that the accident actually occurred in an area between the large Ural cities of Cheliabinsk and Sverdlovsk, east of Kyshtym.[2] We have no reason to doubt either the veracity or sincerity of the reports made by these former Soviet citizens. However, we concluded that additional objective information might be needed for a scientific evaluation of the incident.

The first (and most comprehensive) reports are attributable to Medvedev,[1,2] an internationally recognized geneticist now living in London. During a recent visit to Oak Ridge National Laboratory, he reiterated his claim[2] that the location, year of occurrence, areal extent, and even the type of nuclear accident could be confirmed within reasonable limits by a critical analysis of the extensive USSR radioecology literature based on studies of the contaminated area (over 100 publications).

MEDVEDEV'S CASE

Medvedev's contention was first published in an article in the popular science magazine *New Scientist.*[2] Response to this article has been mixed and in some cases highly critical.[2,6] A careful examination of Medvedev's article provides some support for the reported negative responses. For example, in one line of reasoning, he suggested that 1×10^9 Ci of ^{90}Sr was present in the watershed of one large contaminated lake.[2,7] If it is assumed that the watershed area is one or two orders of magnitude larger than that of the lake itself (10 to 20 km^2), the original level of surface contamination is calculated to be approximately 1 to 10 Ci/m^2. This concentration is 10^3 to 10^4 greater than levels reported in terrestrial studies (~1 mCi/m^2) in the same area. Yet Medvedev concluded that runoff and erosion from the terrestrial zone was responsible for the activity present in the lake. If one assumes that the activity reported to be in the lake's watershed is correct and that all the ^{90}Sr originated from fission in plutonium-production reactors, this would correspond to a reactor operating history of 10^5 to 10^6 MW(t)/year in order to generate the ^{90}Sr waste inventory required.[8] This is clearly inconsistent with the known accumulated history of reactor operation (all types) in the entire world during 1957 and 1958. Further, the total activity of ^{90}Sr wastes in storage at Hanford (the primary U. S. production site for weapons-grade plutonium) in 1978 was 1.27×10^8 Ci[9]—less than Medvedev's estimated 1×10^9 Ci after a much longer time.

Both terrestrial and freshwater studies reviewed by Medvedev indicate that ^{137}Cs was a minor constituent in the contaminated zone. For example, in the terrestrial studies, concentrations of ^{90}Sr reportedly ranged from 0.2 mCi to 3.4 mCi/m^2, and ^{137}Cs concentrations ranged from 4 μCi to 7 μCi/m^2. Further, in another aquatic radioecology study discussed (that conducted by Rovinskii[10]), there is no evidence that ^{137}Cs contributed significantly to the total initial activity. Cerium-144 was the dominant isotope (^{144}Ce/^{90}Sr activity $\approx$ 10 : 1); ^{106}Ru and ^{90}Sr appeared to account for the remainder (^{106}Ru/^{90}Sr activity $\cong$ 1 : 1). The conspicuously low levels or absence of ^{137}Cs in these studies, coupled with the observed levels of ^{144}Ce and ^{106}Ru, argues strongly against an accident resulting in release of materials from a *long-lived-waste* burial facility—the case so firmly maintained by Medvedev.

DISCUSSION

Criticisms leveled at the interpretation of both the scale and type of accident may appear to be warranted by the evidence presented by Medvedev himself. The evidence in Soviet radioecology publications alone indicates a more complex case than that suggested by any observer (including critics) thus far. The inconsistencies in Medvedev's argument might have led some to doubt even the existence of a nuclear accident. However, one must recognize the likelihood that Medvedev encountered difficulties in interpreting information about an actual nuclear accident because he is a geneticist attempting to draw conclusions in areas in which he has not been formally trained, i.e., radioecology and nuclear technology. Thus it would seem prudent first to perform an objective analysis of the information he presented, with no prior judgments being made about either the type or the scale of a potential nuclear accident or an alternative source of radioactive contamination.

An independent source, L. Tumerman,[3] reported encountering a zone of radioactive contamination extending along 20 to 30 km of the highway between Cheliabinsk and Sverdlovsk in 1960. The zone was encountered northeast of Kyshtym, approximately 100 km south of Sverdlovsk. Tumerman, former head of the Biophysics Laboratory at the Institute of Molecular Biology in Moscow, would certainly appear to be a credible scientific observer. The CIA reports, although highly edited, also indicate that some type of abnormal occurrence involving the release of radioactivity was probably associated with the same general area.

The major thrust of Medvedev's argument is that certain radioecology studies were conducted in areas far larger and more heavily contaminated than one would expect to have been set out for purely experimental purposes. For example, two contaminated lakes were reported to be 4.5 and 11.3 km^2 in area;[10] another contaminated lake was estimated by Medvedev to be 10 to 20 km^2 in extent. In addition, at least 21 deer were collected from a contaminated terrestrial site estimated to be at least 260 km^2 in area.[2] The areal estimates were based on the carrying capacity of the system in relation to the size of the sample collected.

We should point out here that we believe that the assumptions Medvedev used to estimate the size of study areas appear to be valid. Our own calculations of the areas required to support the fish populations and the deer herd are in reasonable agreement with his. However, we recognize that *if the total populations were removed*, rather than a subsample, *these estimates would be invalid*. Thus the actual size of the contaminated areas might be much smaller (order of magnitude) than previously stated. Another estimate of the contaminated terrestrial area,[2] based on the migration rate of rodents during a lifetime, is not well-founded and was not considered further. A reasonable estimate of the total minimum area required in the cited studies is well in excess of 25 km^2 under the most conservative assumptions. This area is far greater in size than any known radioecology study area established by deliberate design.

Genetics studies conducted on the contaminated area indicate that the levels of ^{90}Sr were approaching radiotoxic levels (as indicated by significant increases in chromosome aberrations and other genetic effects[2]). Yet much of the research effort reviewed by Medvedev has been on studies of radionuclide transport in the associated ecosystem. Biological studies involving radiotoxicity and radionuclide transport are generally considered to be mutually exclusive because radiotoxicity confounds investigations of radionuclide cycling. The reported levels of ^{90}Sr contamination ($\sim$1 mCi/m^2) are many orders of magnitude above those required for analytical purposes (fallout background $<1 \times 10^{-4}$ mCi/m^2 through 1972)[11] and would be considered high (by the authors) for anything but radiation effects studies. The pattern of ^{90}Sr contamination in a 100-m^2 plot from the contaminated terrestrial area (Fig. 2 in Ref. 2) appears to be almost random—hardly that which one would design for a carefully controlled experiment.

Again, we agree with Medvedev's conclusion about these points. We can also estimate the initial ^{90}Sr surface concentrations in the two lakes studied by Rovinskii[10] by graphical analysis. The estimated areal ^{90}Sr concentrations are both approximately 0.8 mCi/m^2 (mean depth 1.0 and 1.9 m^2, respectively)—far higher than one would consider using in research on such large systems with such a long-lived, radiotoxic material. We believe that there is sufficient evidence that these study areas were not deliberately contaminated for research purposes, but rather that radioecology studies were designed to take advantage of a large, inadvertently contaminated area.

The previous estimate (by Medvedev[2]) of 1×10^9 Ci of ^{90}Sr in the drainage area of one large contaminated lake is much too high for several reasons (one reason was cited previously). The original estimate of 5×10^4 Ci of ^{90}Sr in lake water[2] is perhaps reasonable, but the activity in biota and sediment may have been only a relatively small multiple ($\leqslant$20) of this total, not 1000 times greater as suggested by Medvedev. We believe that this assumption resulted from a misinterpretation by Medvedev of statements made in the original papers.[7,12]

If the lake in question had a closed drainage and the ^{90}Sr activity reported in the water represented only soluble material (no suspended sediment included) under equilibrium conditions, we might obtain a total activity 20 times that in the water for the entire lake ecosystem [i.e., 1×10^6 Ci of ^{90}Sr (Ref. 10)]. Since the lake described appears to have had an open drainage,[2,12] all, or a significant fraction, of the radioactivity may have entered from upstream waterborne (e.g., river) sources (or, conversely, from direct airborne inputs to the lake alone) rather than from its immediate watershed. Equilibrium conditions did not appear to exist in any event.[2,12] Thus the total activity in the lake and its own watershed may have been much less than 1×10^6 Ci. The great disparity between the ^{90}Sr concentrations in other terrestrial areas subjected to study and the surface concentration applied to this lake (and its watershed) are eliminated under this set of conditions.

Medvedev suggests that the nature of the plant and animal species described in research papers indicates the approximate geographical location of the contamination zone. One reference apparently specifies the Cheliabinsk region as the source of biota obtained for research purposes. We would agree that, given enough information, this technique of biogeography would be useful; however, additional sources beyond those already cited by Medvedev would be required to define properly the study area.

CONCLUSIONS

We believe that Medvedev may have reached untenable conclusions about the exact source of the radioactive materials and the extent of the original contamination zone. From all the available evidence, it appears that a fairly large area ($\geqslant$25 km^2) contaminated with relatively high levels of radioactivity ($\simeq$1.0 mCi/m^2 ^{90}Sr reference radionuclide as opposed to $<1 \times 10^{-4}$ mCi/m^2 from nuclear weapons fallout) probably exists in Cheliabinsk Province of the USSR in an area northeast of the city of Kyshtym. The total area of contamination may be significantly greater than indicated; Medvedev's literature citations do not provide information for an accurate estimate of the total area involved.

On the basis of the cited radioecology data, a waterborne release (i.e., involving contamination of a river system, a series of lakes/reservoirs, and associated floodplain/marsh areas) cannot be completely ruled out; however, the occurrence of an accident cannot be conclusively demonstrated. For example, one could speculate and suggest that the contamination resulted from imprudent chronic releases from a large chemical separations complex over a number of y[illegible] However, proponents of this argume[illegible] would ha[illegible] negate the observations of Tumerman and some of [illegible] information provided by the CIA. Thus the most credible case does appear to involve some sort of accidental airborne release.

The disparity of reported $^{90}Sr/^{137}Cs$ activity ratios in terrestrial studies relative to unseparated fission wastes and the dominance of ^{144}Ce activity at the start of one aquatic study suggest (1) that an intervening mechanism for ^{137}Cs removal was present and (2) that long-lived wastes (aged $\gg$1 year) were not prominently involved. The absence of short-lived fission products in radioecology studies suggests that events involving nuclear explosives (weapons test, weapons accident, construction accident involving nuclear explosive, etc.) or reactor accidents as the sole source of the decontamination are not presently very credible unless data collection and analysis were delayed for a period of time.

However, a number of cases can be postulated wherein the venting mechanism is not reflected in the resulting contamination produced. These would include (1) accidental detonation of a small nuclear

531 283

device (either a weapon or construction device) near a radiochemical separations or waste storage facility, (2) conventional explosion following a nuclear criticality either in a radiochemical separations plant or in a waste storage tank, (3) explosion following ignition of highly flammable solvents used in some radiochemical separations, (4) detonation of certain nitrate wastes in a radiochemical separations facility or high-level-waste storage tank, and (5) venting of a high-level-waste storage tank by an explosion resulting from either steam pressure buildup or ignition of radiolytic hydrogen. The range of possible explanations for the contamination zone in Cheliabinsk Province appears to be potentially much broader than the explanations suggested by Medvedev or his critics.

The implications of a catastrophic release from a nuclear waste storage facility are obvious. We believe that an exhaustive critical analysis of the Soviet literature associated with both nuclear technology and radioecology is warranted in order to resolve doubts about the exact nature and consequences, indeed even the occurrence, of the postulated accident.

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Outages at Light-Water-Reactor Power Plants: A Review of 1973–1977 Experience

By R. L. Scott*

Abstract: *The results of a review of outage experience at nuclear power plants for the period 1973–1977 are given. Specifically, the outages experienced were examined to determine causes, frequencies, time, etc., to see if trends were evident or other insights could be obtained. The data reviewed represent 230 reactor-years of experience—58% of the total accumulation in the United States at the end of 1977. Thirteen tables and two figures present the data, and a summary gives the important deductions.*

This article examines the outage experience of light-water-reactor nuclear power plants for the years 1973 to 1977. For this review an outage was considered to be the time accumulated when the generator was not on line, i.e., when no electricity was produced.

The data on the outages were obtained from the periodic operating reports of the individual power plants and/or from data reported by the licensee for the Nuclear Regulatory Commission's (NRC's) monthly publication *Operating Units Status Reports*.[1] The annual compilations of outage experience and

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INFORMATION SOURCES

1. ACCOUNTS BY FORMER SOVIET CITIZENS

2. CIA RELEASES TO PUBLIC

3. SOVIET SCIENTIFIC PUBLICATIONS

551 285

SEQUENCE OF EVENTS

1. MEDVEDEV ARTICLE ON SOVIET DISSIDENCE (11/76)
2. "SCIENCE FICTION" RESPONSE BY SIR JOHN HILL (UKAEA)
3. TUMERMAN REPORT (12/76)
4. MEDVEDEV ARTICLE ON "NUCLEAR DISASTER" (6/77)
5. MEDVEDEV VISITS ORNL (10/77)
6. CIA RELEASE TO U.S. CITIZENS GROUP (11/77)

POPULATION OF MAJOR METROPOLITAN AREAS

YEAR	CITY		
	SVERDLOVSK	CHELIABINSK	KAMENSK-URAL'SKII
1939	423,000	273,000	51,000
1959	779,000	689,000	141,000
1967	961,000	836,000	161,000
1978	> 1 MILLION	> 1 MILLION	NO DATA

CHELIABINSK PROVINCE

YEAR	POPULATION	POPULATION DENSITY/ km^2	AREA km^2
1959	3 MILLION	34	8.8×10^4
1970 TN	3.9 MILLION	36	1.1×10^5
1966	LAND UNDER CULTIVATION - 32 PERCENT		
1966	PRINCIPAL CROPS:GRAIN, FODDER - 97 PERCENT		

CLIMATE

	SVERDLOVSK	CHELIABINSK
TEMPERATURE		
MEAN ANNUAL	1.2 C (34 F)	1.5 C (42F)
MEAN JANUARY	-17 C (4.5 F)	-16 C (2.5F)
MEAN JULY	17 C (63F)	18 C (65 F)
PRECIPITATION (mm)		
MEAN ANNUAL	400-500	~400
SNOW COVER	500-600	~500
PERIOD (days)		
FROST FREE	115	118
SNOW COVER	166	155
ICE COVER	159 (1SET R.)	159 MIASS R.)

SOVIET RADIOECOLOGY STUDY SITES REPORTED DO NOT APPEAR TO HAVE BEEN DELIBERATELY CONTAMINATED

- AREAS TOO LARGE - WATER BODIES (4.5, 11.3, AND $\sim$10-20 SQ. KM SURFACE) AND TERRESTRIAL AREA WHERE 21 DEER WERE COLLECTED.

- ACTIVITY LEVELS TOO HIGH EITHER FOR FIELD OR WASTE DISPOSAL RESEARCH AREAS-^{90}SR UP TO 3.4 MILLICURIE/M^2 IN TERRESTRIAL AREAS AND 0.2 MICROCURIE/LITER IN AQUATIC STUDIES.

- PATTERN OF CONTAMINATION IN ONE PLOT (100 M X 100 M) NOT UNIFORM ENOUGH TO HAVE BEEN DELIBERATELY APPLIED.

531 290

ISOTOPIC RATIOS REPORTED IN
RADIOECOLOGY STUDIES

TERRESTRIAL (9-12 years DECAY TIME)

0.6-3.4 millicuries/m^2 Sr-90
4.-8. microcuries/m^2 Cs-137

AQUATIC (INITIAL CONDITIONS)

Ce-144:Sr-90:Ru-106 ≅ 10:1:1. NO INDICATION OF
Cs-137 AT TIME ZERO

531 201

IL'ENKO'S "HOT" LAKE - AN ENIGMA

1. STUDIES CONDUCTED IN 1969-70 (12-13 years DECAY)

   0.2 microcurie/l Sr-90

   0.025 microcurie/l Cs-137

2. OPEN DRAINAGE: WIDE FLUCTUATION IN RADIOACTIVITY CONTENT

3. LARGE SYSTEM ESTIMATED TO BE APPROXIMATELY 20 km^2 IN AREA

   OVER ONE QUARTER METRIC TON OF PIKE (ESOX LUCIUS) COLLECTED DURING 7 months IN 1970; 3 IN 10-12 kg CLASS

4. ESTIMATED TO CONTAIN 10^5 -- 10^6 Ci OF Sr-90

POTENTIAL ACCIDENT MECHANISMS INVOLVING REPROCESSED WASTES

1. NUCLEAR CRITICALITY

2. CONVENTIONAL EXPLOSIONS, FIRES

   A. HIGHLY FLAMMABLE SOLVENTS (ETHERS)
   B. SOLVENT RESIDUES, NITRATE WASTES
   C. AMMONIUM NITRATE WASTES
   D. RADIOLYTIC HYDROGEN-OXYGEN MIXTURES

Cs-137 REMOVAL MECHANISMS FOR REPROCESSED NUCLEAR WASTES

1. VOLATILITY AT HIGH TEMPERATURES (> 400 C)
2. RADIOISOTOPE PRODUCTION

OUR CONCLUSIONS INDICATE THAT AN EXHAUSTIVE ANALYSIS OF THE SOVIET LITERATURE IS WARRANTED

- MEDVEDEV'S CONCLUSIONS ABOUT SOURCE AND EXTENT OF CONTAMINATION ZONE MAY BE UNTENABLE.
- EVIDENCE EXISTS FOR FAIR-SIZED AREA ($\geq$ 25 SQ. KILOMETERS) ACCIDENTIALLY CONTAMINATED WITH HIGH LEVELS OF RADIOACTIVITY ($\sim$1 MILLICURIE/M^2 ^{90}SR) IN CHELIABINSK PROVINCE IN THE U.S.S.R.
- BEST EXPLANATION PRESENTLY SEEMS TO INVOLVE AN ACCIDENT, ALTHOUGH A CHRONIC WATERBORNE RELEASE CANNOT BE RULED OUT.
- REPORTED ISOTOPIC RATIOS (IF ACCURATE) RULE OUT NUCLEAR EXPLOSIVE OR REACTOR ACCIDENT AS SOURCE.
- DOMINANCE OF CERIUM-144 AT START OF ONE AQUATIC STUDY (^{144}CE:^{90}SR ACTIVITY RATIO $\sim$ 10:1) SUGGESTS THAT FISSION PRODUCTS WERE 1-2 YEARS OLD WHEN RELEASED.
- ISOTOPIC RATIOS IN TERRESTRIAL STUDIES (^{90}SR:^{137}CS ACTIVITY RATIO $>$ 100:1) INDICATE THAT AN INTERVENING CESIUM REMOVAL MECHANISM WAS INVOLVED.
- COMBINED INFORMATION SUGGESTS THAT EXPLANATIONS INVOLVING RELEASE FROM A RADIOCHEMICAL SEPARATIONS/HIGH-LEVEL WASTE STORAGE FACILITY ARE PRESENTLY MOST CREDIBLE.

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RATIOS OF FISSION WASTE PRODUCT ACTIVITIES TO Cs-137

ISOTOPE	DAYS 350	500	700	1800
Sr-89	0.45	---	---	---
Sr-90	1.0	1.0	1.0	1.0
Y-91	0.92	0.16	---	---
Zr-95	1.1	0.23	---	---
Nb-95	2.5	0.54	---	---
Ru-106	0.84	0.64	0.44	---
Ce-144	14.0	9.6	5.7	0.39
Prn-147	1.8	1.6	1.4	0.62
PERCENT OF INITIAL ACTIVITY	2.4	1.5	1.0	0.3