What We Can Learn from Fukushima

This interview with LaRouche Pac editor Alicia Cerretani, took place three days after the March 11 Fukushima accident. We present this edited version as a tribute to Mike. It exemplifies his spirited support of nuclear fission, and his passion for educating others.

Question: Please tell us about your background.

Fox: I retired after 40 years in the nuclear industry at Hanford and Idaho National Engineering Lab. I have taught thermodynamics at the university level. I have a Ph.D. in physical chemistry from the University of Washington.

Physical chemistry is kind of a discipline in between chemistry and physics. For example, in my five years of graduate school, I almost never touched a test tube; it's more theoretical than dirty lab work. And I have a mathematics and chemistry B.S.

Question: What is your view of the Fukushima situation?

I'm not a nuclear engineer, but know a lot of people who are reactor engineers, and I've talked with them about the failure mode at TMI and the failure mode at Chernobyl. It's a very, very interesting discipline that these people have. They go through the sequence of events that lead to the accident. And by knowing what happened, that's how we make reactors safer.

It turns out that failure is very, very informative—we learn a lot. Probably we learn more from failures than we do from successes, because the envelope of variables for success—temperature, pressure, viscosity, concentrations—can be reasonably small, in that if we run a successful test, why then we congratulate ourselves on how brilliant we are, but we may have been operating right at the edge of failure, so we don't learn as much as we could if we had actual failure. So that's the general philosophy, where I'm coming from.

I know people who have been to Chernobyl and who have been directly involved with the health effects of radioactivity, the environment, wildlife, plant life, isotopes, and all that. My favorite author, by the way, on the Chernobyl events is one of your favorites—Zbigniew Jaworowski.* He's super, and extremely knowledgeable; his writing skills are just perfect for me. Because as soon as he says something that raises a question in my mind, the next couple of sentences answer the question. He's a guy you don't want to lose contact with.

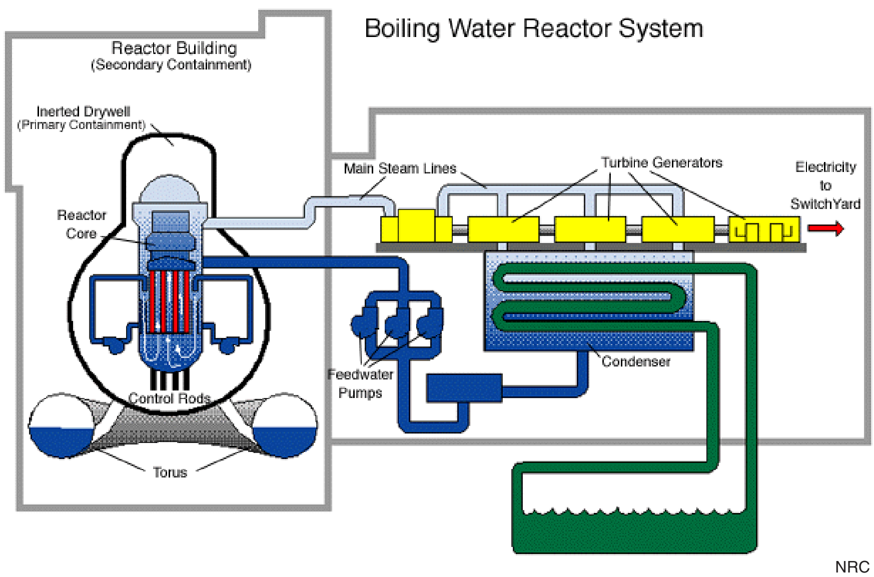
Question: There's just so much ignorance about how nuclear reactors actually work, so when people hear about the accident and explosion, their imaginations get carried away in fear. From your perspective, can you give people a sense of what you know happened with the reactor and what the real dangers are in a situation like this?

Fox: I know some of the people who did the examination of the fuel debris ob-

HOW A BOILING WATER REACTOR WORKS

Water circulates through the reactor core, where the fission process heats it to boiling, converting it to steam. Steam separators remove water droplets from the steam, and the steam is sent to the turbine generator, which produces electricity. From the turbine, the steam goes to the condenser, where it is condensed into water. The cooled water is pumped from the condenser and sent back to the reactor core to begin the cycle again.

The control rods in the BWR come up from the bottom, instead of from the top. There is also a Torus or Suppression Pool below the reactor, which is used to remove heat in an emergency.



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A nuclear fuel assembly (left). The long tubes are zirconium-alloy-clad fuel rods which are fastened together into large bundles that form the core of a nuclear reactor. Uranium oxide fuel pellets are stacked inside each rod. Individual fuel rods are shown in the inset.

tained from the Three Mile Island reactor in 1979, so we know damn well what happened.

Visualize a reactor core with 100 fuel assemblies, each fuel assembly maybe containing 100 fuel rods held in a vertical position. A fuel rod is typically composed of an alloy of zirconium, and it contains the actual fuel pellets that are loaded into it when they are fabricated. These rods go into the reactor and, to make a very long story short, by manipulating the water, water pressure, and heating the water, we extract heat from the fuel and pump it around to heat exchangers. Then that is expanded into turbines, and the turbines drive generators, and we get electricity.

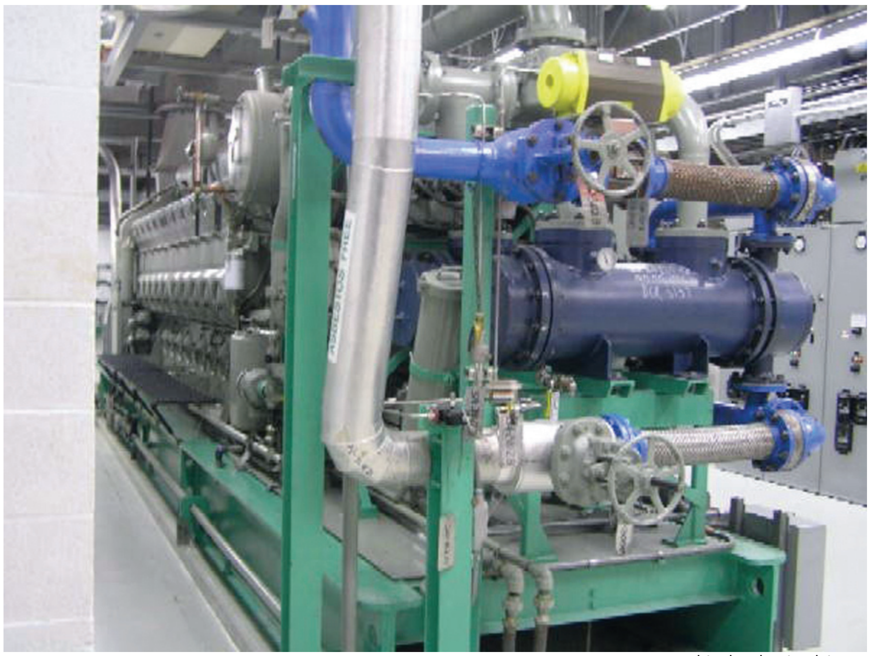
Now, what happens in an accident like Three Mile Island? The TMI accident is analogous to what I believe happened in Japan. You have an accident, and you have a power failure. It turns out that some of the power that some utilities use to run the plant—I think we're trying to get away from it in the United States—comes from off-site. Here in the Northwest, we get power from our hydroelectric facilities coming into the power plant to run back-up. Now, suppose we lose the off-site power, as they did in Japan. This means that the circulation pumps in the reactors shut down.

In the United States we have anticipated that by installing huge diesel generators. And these diesel generators are quite capable of running a minimum supply of electricity, including instrumentation, circulation pumps, and so forth. They are huge—big enough to run small ships.

And part of the inspection process in our reactor in Richland is to inspect and start up these back-up systems without the use of off-site power. Now the way they do that is, that these diesel engines can be started with large batteries. And they do that; on a regular basis they fire them up and start them, just to make sure they are operable.

Now in Japan—and this is fragmentary information that I've gotten—they had back-up diesel generators, and they were capable of generating onsite power from them, but the diesel fuel was located outside the reactor building, and these got broken. I don't know whether it was the earthquake that broke them, or the tidal wave that broke them, but the back-up diesel lost power because it couldn't get fuel.

And so—I don't know what the euphe-



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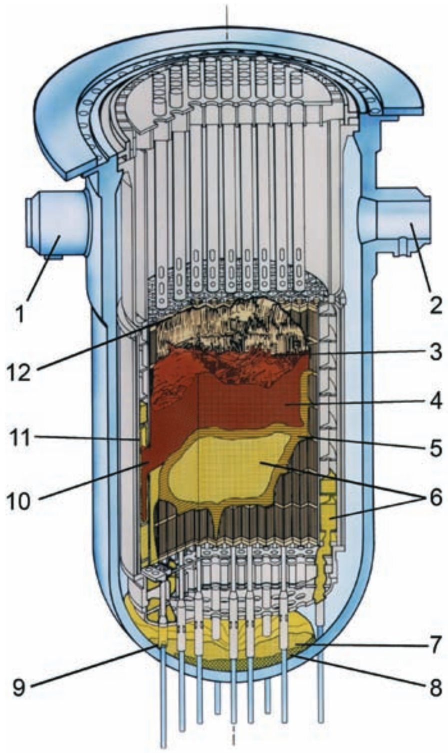
Nuclear plants have a back-up power supply to keep the emergency systems (water cooling pumps) operating if there is a power loss to the grid. At the three damaged Fukushima plants, the back-up diesel generators lost power in the flood waters of the tsunami, leaving reactor fuel assemblies uncovered. Here, a back-up diesel generator.

NRC DIAGRAM OF TMI CORE WITH MELTED FUEL

This Nuclear Regulatory Commission diagram depicts what happened in the 1979 Three Mile Island accident where reactor fuel slumped to the bottom of the boiling water reactor pressure vessel. Dr. Fox notes (based on what was known just two days after the accident) that this might be the case with the damaged Fukushima reactors.



Key

1. 2B inlet
2. 1A inlet
3. Cavity
4. Loose core debris
5. Crust
6. Previously molten material
7. Lower plenum debris
8. Possible region depleted in uranium
9. Ablated incore instrument guide
10. Hole in baffle plate
11. Coating of previously molten material on bypass region interior surfaces
12. Upper grid damage

mism is—but Tokyo Electric Power Company was screwed, because it couldn't pump water. Then the reactor starts heating up and driving off the cooling water that is in the core, in the pressure vessel. As it drives off steam, the reactor top, the tube assemblies, become uncovered, bare, and exposed to air and steam. . . .

Then a sequence of events happens that is very helpful to understand what you see on television today.

Once these fuel rods become uncovered, they are still hot. I mean very, very hot—hundreds of degrees—and a chemical reaction occurs that we learned in high school. The fuel rods become uncovered and hot, and their zirconium fuel cladding then has a hot metal/water reaction.

Anytime you heat a metal to very high temperatures and throw steam around it, what happens is that oxidation takes place. The zirconium is converted to zirconium oxide, and the by-product is hydrogen.

One talk show guest I heard, a so-called "expert," said that hydrogen and oxygen are generated by that process. That's not true. Oxygen is consumed by oxidizing the metal. So you get zirconium oxide plus hydrogen.

Now the zirc oxide is now not a metal, but it's a brittle ceramic oxide . . . and it begins to slough off the reactor fuel buttons that are loaded into the fuel rods. All that becomes free, and the fuel slumps to the bottom of the pressure vessel.

So that's what happens with the zirconium-clad fuel; it goes to the bottom of the pressure vessel.

The hydrogen, on the other hand, is vented and it was caught—collected—in the exterior building in Japan, where it built up in constant pressure. And with hydrogen concentration, I know, the flammability in air is about 4 percent. The explosion limit is 6 or 8 percent. So it doesn't require an entire room of hydrogen to create a problem.

Once it gets up to that 8 percent. . . . When dealing with hydrogen, you always assume that there is an ignition source around—anything from a match to a light switch, which can ignite the mixture. And kaboom! Away we go. And the utility loses the reactor. It's destroyed.

So, what upsets me more about the media coverage is that it is almost making a parody of it. They have zero concept of relative risk. The big problem facing the Japanese now is not the reactors, it's the 80,000 people that are missing from the tidal wave and other damage caused by the earthquake.

There is essentially no health risk involved from the reactors.

Another thing that drives me nuts, is that we are not told what kind of radiation is involved. It's a big, big, big difference, whether it's tritium or whether it's strontium, cesium, or whatever. Because these come from different sources in the reactor system, and would tell me what kind of damage is likely to have occurred.

But all the news media think they have a nuclear "expert" on nuclear power, but they are coming from groups like the Center for American Progress, the far left-wing group in Washington, and others that I've never heard of.

I'm a member of the American Nuclear Society, and I've never heard of these people. I'm also, as I said, familiar with the failures at Chernobyl. And these guys, the so-called experts, so far as I know, have never been involved with doing health studies or environmental studies at Chernobyl. They are not experts in failure-mode analysis or risk analysis for reactors, but they are obviously very good at self-promotion and very pleased with themselves to get on television.

I have nothing but contempt for these people, who are reciting 25-year-old scare stories for their own self aggrandizement and doing a dreadful job of informing the public. How's that for candor?

Question: That's why they picked them, and that's why they're "experts." Not because they know anything about the disaster.

Fox: They're certainly experts in self-promotion, and they know some of the lingo. And most of the lingo that they use is old lingo from the TMI accident, but essentially the health effects of TMI are zero, and I expect that the health effects of the Japanese reactors to be essentially zero too.

I've worked in the nuclear industry for

Report of The President's Commission on the Accident at Three Mile Island: The Need for Change: The Legacy of TMI

Three Mile Island personnel in protective clothing cleaning up the contaminated auxiliary building in October 1979.

40 years, and I've operated and managed radio-chemistry labs and plutonium labs, and I know what I'm talking about. And, since I have people whose health and safety are important to me, and are friends, I never took my radiation advice from people like this, or Greenpeace, or John Gofman, or any of the other opportunists, because they are invariably wrong—whether it's plutonium chemistry, or the health effects of radiation, or whatever.

And the Japanese: I see them monitoring children and adults, but they are doing it in a proper, very, very, very conservative way. And that's the way we do things.

It probably aggravates the situation to see a guy in what we call SWP clothing—safe work permit clothing—monitoring a child who is in street clothes, but that's how you do it.

Sensitive Instrumentation

Another problem involved with this, by the way, in communicating, is that our instrumentation in 2011 is hugely sensitive in the measurement of radioactivity. There is a false presumption that if the radiation is detectable, it creates cancer, it creates death. That's absolutely not the truth.

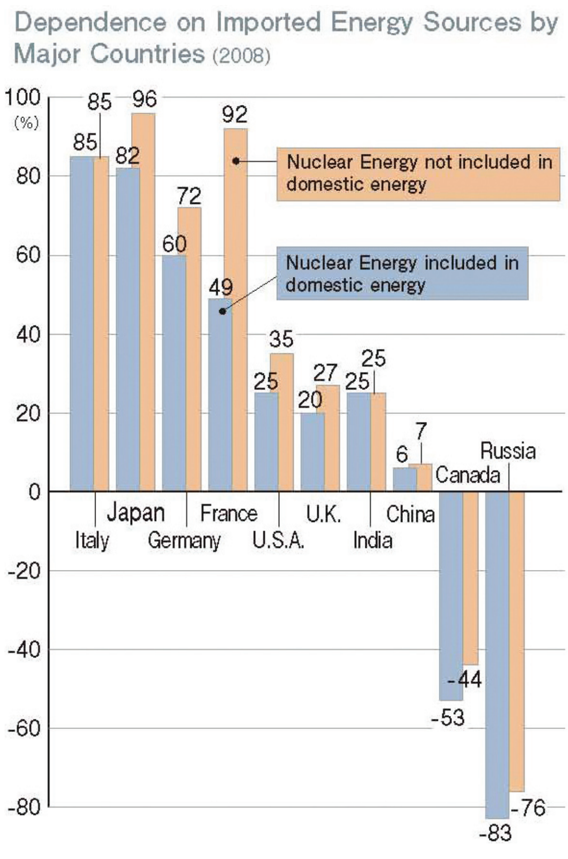
We have detection equipment now that can detect chemical elements off the periodic chart at the parts-per-million level. When I took quantitative analysis, we were happy with parts per thousand! Now the detection limits are parts per trillion, and the detection of radioactive materials is even lower than that—another factor of 1,000 to 10,000 times lower than that.

So a scientist can stand up and say "Yep, we detected it, it's there," but if you don't have any sense of perspective and the magnitudes of what their detection equipment is telling them, why you can easily paint a scary story, and a lot of the reality is left out of the discussion. It's one of my pet peeves, since I've operated some of those pieces of equipment.

It's a big financial hit for sure, but they're making a parody out of it. Because Japan has to have electricity, and most people in the United States don't appreciate what electricity has done for them as a nation. It provides entertainment, it provides highly productive workers, it provides help in our national security defense systems.

Electrical energy is a substitute for human backs, or for slavery. Now, we have a rather terrible choice here, and if we want to go down the road here to more reliable, low-cost electricity, we can either have it or we can not have it. And I grow weary of people who think that we can get abundant energy from sunbeams and gentle breezes. That's just not the case. That's one thing I learned in teaching thermodynamics.

There are some things about energy that are inviolate. For these people to be scaring people about nuclear power plants, especially when they have the history of the TMI incident, is dishonest. The Japanese have much, much, much bigger problems to solve right now. . . .



JAPAN'S VULNERABLE ENERGY SUPPLY SITUATION

Without indigenous energy resources, Japan is dependent on imports for 96 percent of its primary energy supply. If nuclear energy is included in domestic energy, Japan is still 82 percent dependent on imports. Increasing reliance on nuclear power, including fuel reprocessing, has traditionally been part of Japan's energy policy.

Question: It's reported now that not only the Fukushima nuclear plants were damaged, but other reactors were demolished, including coal-fired plants and an oil refinery that went up in smoke. What are you looking at in terms of actual plant damage?

Fox: This morning's news is reporting that there may be a possibility of three reactors undergoing this process of the fuel becoming uncovered and slumping to the bottom of the pressure vessels. So there is going to be a lot of damage there. The damage is being contained both by the pressure vessel and the first containment building, which is robust concrete.

You won't be able to tell how much damage unless you get very close to it. I imagine that they will follow that TMI clean-up pretty closely in Japan. We certainly got a lot of experience doing that.

I hadn't heard that Japan had lost coal plants. I do know that one of the oil refineries is burning. But, Japan is in a tough situation. They don't have any indigenous supplies of coal or oil. And they are very smart and great people, so they went down the road to build domestic nuclear power plants. Regrettably, Japan itself is on a geologic fault and so they have to engineer around that. . . .

Defense in Depth

Question: What you said about electricity is key, and I haven't surveyed a lot of the other damage to the infrastructure. But if you juxtapose the situation in Japan, with what happened, say, in Haiti: Haiti never had that kind of infrastructure, the way Japan has built theirs up, so the damage done to Haiti was much more severe, because they didn't have this higher energy flux dense capability that the Japanese do. In Japan, we may be talking about three reactors that are down, but is it the case that the infrastructural integrity granted by the power plants, and the power plant itself, actually fared better than other infrastructure that was involved in the earthquake and the tsunami?

Fox: Yes, what we call defense-in-depth, how to contain the fission products, has worked very well. The pressure vessel is intact, the first containment building is intact, and it's very unlikely that they will be breached.

There are additional safety measures that they could take. I don't know why they are not pouring in borated water into the reactors, but they apparently are not. Boron is a wonderful element that absorbs neutrons and stops nuclear fission reactions. That's one way to stop it.

But, yes, the infrastructure at the power plants is pretty much intact in terms of anticipating the kind of accident that occurred. The problem is that they engineered for—it's called the design basis accident—and that was, I think, somewhere around a 7.0 magnitude earthquake. Well, this was a 9.0, so the plants were not designed for a 9.0. Something gave, and in this case it was the fuel supply to the diesel generators that was terminated. . . .

Especially given the hardship that the Japanese people face now with water shortages, food shortages, and loss of infrastructure, just in living in communities there. I don't know what the Japanese are going to do—are they going to bring in floating nuclear reactors?

Question: They could; Russia's not too far away. The Russians have a design for small floating reactors. I know the Russians are bringing in natural gas.

But let me ask you this: What do you think we could learn from this situation? You mentioned that we learn the best, sometimes, from the failures. So what do you think we can learn from the earthquake and tsunami in Japan?

Fox: Well, it's conjectural, but we can learn how to build more robust cooling systems, and more robust back-up diesel systems. And the Japanese, at least, are going to have to build more robust reactors to withstand a 9.0 earthquake. So the guys who are expert in risk analysis and failure-mode analysis are going to be going through this with a fine tooth comb, and making observations that we haven't even thought of.

Chernobyl was a different thing. They were almost begging for an accident there. They had a design flaw, which is called a positive void coefficient: At low power, the cooling lines in the reactor could flash to steam. Now that's a problem that was recognized 40 or 50 years ago. But the Soviets designed the Chernobyl reactor in such a way that as the liquid water in the cooling system flashed to steam, it *increased* the power output of the reactor. That's where the word "positive" in positive void coefficient comes from—it increased power as the liquid water flashed to steam. In all other reactor types, there is a *negative* void coefficient, so they have a tendency to shut themselves down.

I have a friend in Tri-Cities [Washington] who was involved in the design of reactors, and he personally told the Russians—and I know this happened in a number of cases—he personally told the Russians in the 1970s that their RBMK-1000 had a major flaw in it, its positive void coefficient. But the Russians just pressed on and built these things, knowing that the reactors had a design flaw that was waiting to happen. And it did.

There's a whole bunch of other things that the Russians did or did not do, in terms of violating their own safety rules, but the design flaw was a showstopper. . . .

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Notes

* Zbigniew Jaworowski's most recent article on Chernobyl, "Observations on Chernobyl after 25 Years of Radiophobia," can be found here.