HIGH-LEVEL RADIOACTIVE WASTE ("Spent Fuel") at

Diablo Canyon Nuclear Power Plant (Diablo)

--Updated Fact sheet, April 2014

What is "Spent Fuel"?

The terms "spent, used or depleted fuel" are euphemisms, referring to the fuel's usefulness for generating electricity, NOT to its radioactive content. Actually, high-level radioactive waste ("spent or used fuel") is the fuel from the hot core of commercial nuclear power plants. This highly irradiated fuel is the most intensely radioactive material on the planet. Depending on its time out of the reactor, it can give a lethal dose of radiation in seconds to an unprotected person standing next to it. Highly irradiated waste accounts for about 95% of the radioactivity generated in the last 50 years from all sources, including nuclear weapons production.

Uranium is first enriched, then processed into fuel rods and loaded into nuclear power reactors where it undergoes the nuclear fission reaction. After three to four years it becomes inefficient to produce electricity and is removed from the reactor core. This "spent or used" fuel is then about 1 million times more radioactive than when it was first loaded as "fresh fuel." The increase in radioactivity is due to the formation of more than 200 intensely radioactive radioisotopes during the fission process, such as cesium 134 and 137, strontium 90, cobalt 60, and plutonium 239. For each 1,000 megawatts a nuclear power plant produces about 30 metric tons of high-level radioactive waste. Diablo produces about 70 tons annually.

Half-Life vs Hazardous Life

The half-life of a radioactive isotope is the amount of time it takes for one-half of the quantity of that isotope to naturally decay; either to a stable form, or to another radioisotope in a "decay chain." Generally, 10 half-lifes are called the hazardous life of an isotope. Example:
Plutonium-239, the most toxic isotope, has a half-life of 24,400 years. It remains dangerous to human health for a quarter of a million years, or about 8,000 human generations. As it decays, uranium-235 is generated; half-life: 710,000 years. Thus the hazards of irradiated fuel will continue for millions of years.
However, when contemplating the risks of accidents or acts of malice, mid-life fission products, such as strontium 90 and cesium 137 are more dangerous because, unlike the heavy plutonium 239, they are more easily dispersed over large areas. Both are strong gamma ray emitters and accumulate in the food chain. Cesium 137, with the half-life of 30 years (hazardous 300), is of particular concern because, in fires, it assumes the consistency of talcum powder.

Volume vs Radioactivity

Highly irradiated fuel makes up only about 1% of the total volume of all radioactive wastes generated in the U.S., but it contains about 95% of the radioactivity. Presently, there are nearly 70,000 metric tons accumulated in the United States, most of it in water-filled pools at the 67 reactor sites. This fuel contains approximately 60,000,000,000 curies of radioactivity.

What's a Curie?

A curie is a large unit: 2,224,000,000,000 (over 2 Trillion) radioactive emissions, or 'counts' per minute. Natural radiation, measured with a simple Geiger counter, is typically between 2 and 20 counts per minute. Each of these emissions has the potential to initiate a cancer.

How much is stored at Diablo now?

As of November 2013, there were 2,848 waste units, called "spent fuel assemblies", stored at Diablo.
"Spent fuel" accumulates as bundles of rods in so-called "spent fuel assemblies". At Diablo, an assembly consists of 225 fuel rods, each about 12 feet in length. Each of Diablo's two reactors operates with 193 assemblies at a time. Every 18 to 21 months, a portion needs to be replaced, adding another 70 to 90 spent fuel assemblies to the storage inventory with each year of operation. When coming out of the reactor, these assemblies are so hot (radioactively and in temperature) that they need to cool off under 40 feet of water for at least 5 years. In November 2013, Diablo's spent fuel pools contained 1,920 assemblies. In addition, another 928 assemblies are stored in dry casks, generally considered a safer means of storing high level nuclear waste for prolonged periods of time.

Radiation amounts

The total amount of radioactivity contained in the assemblies depends on the amount of time out of the reactor and the degree of "burn-up" during the time in the reactor. After 1 year, a "low burn-up" assembly contains 2,500,000 curies, after 50 years about 100,000 curies (US Dept. of Energy, 4/15/1980). For some time now, PG&E has been using "high burn-up fuel" in Diablo's reactors. As a result, radioactivity is as much as doubled in the "spent fuel" waste, exacerbating the problems with storing it on-site. By now, Diablo's waste pools contain about 80% high burn-up assemblies. Given the difficulties of calculating the precise amounts, plus averaging the radioactivity over the length of time out of the reactor, plus the difficulty in imagining what millions of curies actually mean, a better way of explaining has been developed by Dr. Marvin Resnikoff, Radioactive Waste Management Associates, New York, one of the Nation's foremost radioactive waste experts. He compares the amount of long-lived radioactivity in a spent fuel assembly with the amount of long-lived radioactivity released by the Hiroshima bomb. **[NOTE: This is for radiation amounts comparison purposes only. A nuclear bomb explosion cannot happen with radioactive waste]**

As a yardstick Dr. Resnikoff uses cesium 137, which has a half-life of 30 years [hazardous life 300 years]. Cesium 137 is the most worrisome isotope in accidents or acts of malice for several reasons:

1. Cesium 137 is a strong gamma ray emitter.
2. In 10 year old spent fuel, cesium 137 contributes 21% to the total amount of radioactivity, more than any other radioisotope in High Level Radioactive Waste.
3. Cesium 137 assumes the consistency of talcum powder in fires, i.e. it is easily carried off site in explosions or fires.
4. Much of the off-site contamination at Chernobyl was due to cesium 137, rendering there a 12,400 square mile area as uninhabitable for decades (SLO County has 3,307 square miles).

Using Resnikoff's cesium 137 comparison, it is estimated that, for the low burn-up fuel, each spent fuel assembly contains on average the equivalent of 10 HIROSHIMA Bombs in long-lived radioactivity. That means that each of Diablo's two pools may contain the radiation equivalent of as many as 20,000 Hiroshima Bombs in long-lived radioactivity. Compared with the Chernobyl accident, each of Diablo's pools may contain up to 20 times more cesium 137 than was released there.

How much does PG&E plan to store in the future?

According to PG&E, Diablo will generate a total of 4,310 assemblies by the end of its current licenses in 2025. There are presently no possibilities or even plans to transport any "spent fuel" off-site before 2025. Diablo would then be storing about nine times more than was projected when the plant was built! If Diablo should get re-licensed, as much as an additional 2,200 assemblies could conceivably accumulate. It is important to understand that until now the two pools have been kept at or near capacity.

It is also important to understand that both wet and dry storage technologies were developed before 9/11. Though sturdy, neither are designed to withstand a 9/11 type terrorist attack or other act of malice because the NRC had taken the position that such attacks could not happen in the U.S. and therefore did not require the operators of nuclear power plants to plan for it. In addition, no one can predict what kind of precision weapons, such as smart bombs or laser guided missiles, will find their way into the wrong hands between now and 2050. Moreover, the plant and spent fuel storage sites are located next to or near 13 earthquake faults!

High density pools

In 1986, the pools at Diablo were filled to capacity under their original design: about 270 SFA's each. PG&E, with NRC approval, re-racked the pools at Diablo. Neither SLO County nor any other county or state agency was part of the decision making. As a consequence, both pools contain at the present time nearly four times more "spent fuel" than they were originally built, licensed and designed for.

But the difference between the original "low density pools" and today's "high density pools" is not just the quadrupling of the amounts. Far more of concern is that "high density pools" are much more likely to catch fire than low density pools.

The assemblies consist of hundreds of long and very thin tubes, which are as narrow as pencils. The cladding (wall) is made of zirconium alloy, a flammable material which can ignite spontaneously if the cooling water drops below a certain level due to accidents, terrorist attacks or earthquakes. Such a zirconium fire would release large amounts of radioactivity (cesium 137) into the environment.
In October 2001, the NRC determined that a fire in a high density spent fuel pool is comparable in its consequences to a severe reactor accident. This finding was verified by a study of the National Academy of Sciences in 2005.
At Diablo, the pools contain much more dispersible radioactivity than the reactors; yet the pools are located outside the containment domes in unprotected sheetmetal structures of (especially against air attacks).
Just this year, the "Expedited Spent Fuel Transfer Proceeding" of the NRC revealed that a relatively small spent fuel pool fire could contaminate an area 9,400 square miles large and cause the displacement of its residents for decades.
The entire area of SLO County is 3,307 square miles!

Risk Assessments

A catastrophic release of radioactivity at Diablo could render most, if not all, areas of SLO County uninhabitable for 300 years, depending on the duration of the release and the prevailing winds at the time. Clean-up costs could be in the tens of BILLIONS of dollars.
A Chernobyl type reactor accident cannot happen at Diablo. However, a spent fuel pool fire (or another type of a severe reactor accident) would have comparable consequences for SLO County and beyond. The likelihood of such an event has been down played by the industry and the NRC. Until 9/11, the NRC has maintained that an event like 9/11 could not happen in the US. Since 9/11, the NRC claims that the likelihood of a pool fire caused by an act of malice cannot mathematically be calculated and therefore doesn't need to be considered by the industry.
The industry and the NRC have been using "Probabilistic Risk Assessments (PRA's)." Close scrutiny, however, reveals a substantial flaw in using PRA's: Factors which cannot be mathematically calculated are ignored.
For example, human error is left out of the calculations despite the fact that it played a role in 74% of all mishaps at nuclear plants (1987 figure).
The resulting probability predictions do not remotely match the real life occurrences: Classical PRA predicted the Three Mile Island risk as once in three million reactor years. In reality it happened after 300 reactor years (all reactors worldwide combined). For Chernobyl it was once in 10 million reactor years, but it happened after 500. Moreover, combinations of factors, such as happened at Fukushima, are not taken into consideration. The combination of a 9.0 earthquake, followed by a tsunami, too low seawalls, back-up generators placed in the basement and battery power for just 8 hours were not foreseen or thought of as ever possible. Yet, Fukushima happened after some 14,000 reactor years.
Nevertheless, the NRC keeps using PRA's.

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