Yoshioka's memo for Fukushima accident (No.70)

2014-Jan-03, Ritsuo Yoshioka

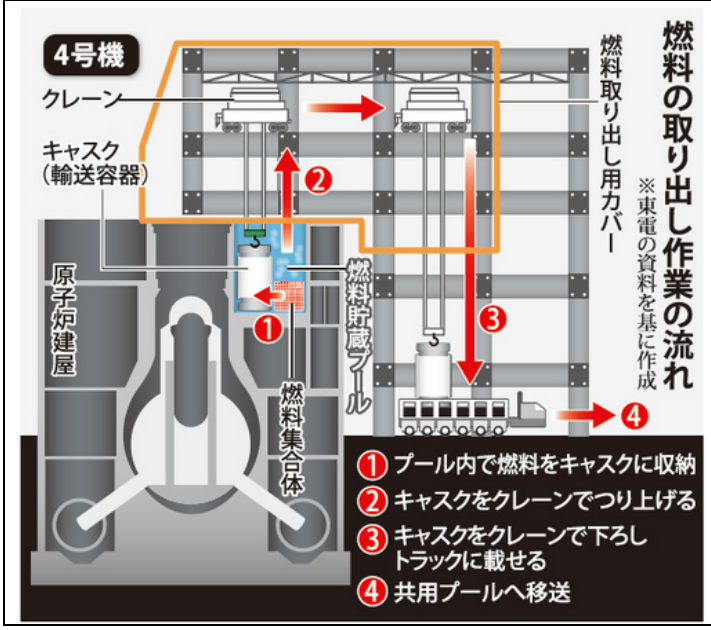
What is the risk for spent fuel transportation from Fukushima-4?

Even in Japan, a certain major magazine (Weekly Asahi, 2013-11-8) or some citizens are worrying about the risk for spent fuel transportation from Fukushima-4. Regarding this issue, Japanese NHK-TV explained the transportation procedure of nuclear fuels in the spent fuel pool of Fukushima-No.4 plant. (2013-11-18)

http://www3.nhk.or.jp/news/1115genpatsu/index.html?utm_source=dlvr.it&utm_medium=twitter

There are about 1,500 fuel assemblies at the F-4 pool (about 500 are hot fuels which were discharged from the core, about 800 are old spent fuel, and about 200 are new fuels). All fuels are expected no fuel failure, except 3 fuels having small leak for the last 40 years operation.

Since the original fuel-handling crane was destroyed by the hydrogen explosion on March 2011, TEPCO attached a temporary crane with holding iron frameworks (see below figure). This iron frame is independent to the original reactor building (self-standing).

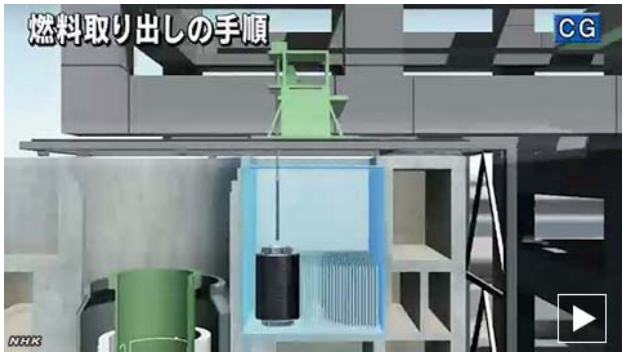


1) Using this crane, 22 fuel assemblies are moved to the fuel cask in the pool water.

2) Cask is lifted-up and moved.

3) Cask is lowered to the track on the ground

4) Cask is transported to the common pool near the reactor (100m west of F-4).



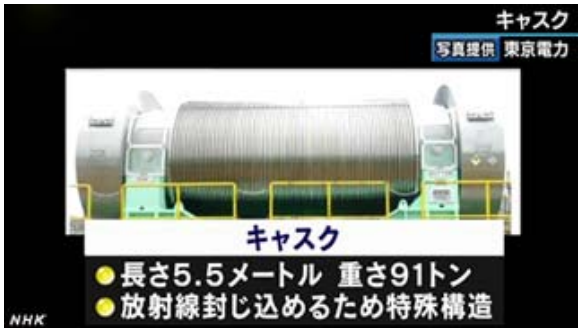
The above procedure is animated in the following URL.

http://www3.nhk.or.jp/news/1115genpatsu/index.html?utm_source=dlvr.it&utm_medium=twitter

This cask has been used in all BWRs for the last 40 years. Its total weight is about 100 tons.

One cycle of the above transportation procedure takes one week, and about 70 transportation tasks are scheduled. So, whole task will take one year from November 2013 to December 2014.

(22Asy x 70times = 1,500Asy)



Actually, there are many risks for this task. TEPCO shows countermeasures to prevent accidents in the following URL, but it does not show what will happen if the accidents occur.

http://www.tepco.co.jp/nu/fukushima-np/handouts/2013/images/handouts_131115_08-j.pdf - search='%E7%A6%8F%E5%B3%B6+%E7%87%83%E6%

1) Earthquake risk for spent fuel pool (radioactivity release, meltdown, re-criticality)

★3rd/4th/5th floor walls were destroyed by the hydrogen explosion (see upper right photo). Then, TEPCO added some support under the spent fuel pool, also calculated the seismic strength for this condition, and it is concluded that it has still enough seismic strength. But, it is true F-4 building is not strong as before. If fuel pool is destroyed, pool cooling becomes impossible, and then finally meltdown may start. Let me consider if meltdown occurs or not.

It is 3-years after the accident, and the decay heat is very small. It is 0.005% of the rated power. Since average rated power of each fuel assembly is 4.5MW, decay heat of each assembly is only 200 watts (=4500KW x 0.00005). And, total heat generation of 1300 spent fuel assemblies is 300KW (=4500KW x 1300 x 0.00005). So, even if pool water is lost, natural air circulation can cool this heat.

Total UO2 weight of 1500 fuel assembly is 300-tons. Of course, if this 300-tons collapse to the bottom of the pool, and become a big block, and if this block is thermally insulated, temperature of 300-tons will increase infinitely. But, there is thermal convection and heat transfer even in the air. So, even if pool water is lost and all fuel pellets fall down to the bottom of the pool, meltdown will not occur.

★Even if pool water is lost, it does not reach critical, because there is no water for neutron moderation. If 300-tons becomes one big block, it does not reach critical, because there is no appropriate arrangement between fuel rod and water for neutron moderation. I have made Monte Carlo calculation for this geometry in 2011, and it was uploaded in the web site.

★If fuel cladding breaks, inner FP gas such as Xe/Kr is released. But, almost all Xe and Kr decayed. Iodine is easy to be vaporized, but I-131 already decreased. Of course, some radioactivity will be released, and it becomes very difficult to collect dispersed fuel pellets, which contaminate the reactor. This will be some risk, but its risk is limited near F-4, where already contaminated by 3 reactors (F1/2/3) meltdown.

★If pool water is all lost, there is no radiation protection, and further fuel handling becomes impossible. This is not catastrophe. One countermeasure is to inject concrete like Chernobyl accident. This will be a real risk, and this is why we have to transport F-4 spent fuel as soon as possible.

Also, spent fuel pools of F1/F3, which had hydrogen explosion as F4, have the same risk.

2) Drop accident risk. (Radioactivity release, meltdown, re-criticality)

★Highest position of the cask is 32 meters, and this cask has been tested from 17 meters high. So, if cask drops from 32m high, it will break.

Fuel cladding is not strong as cask, so radioactive fuel material is dispersed. This is not happy situation, but it is not catastrophe. Contamination is limited near the ground of F-4 reactor.

★If cask water is lost, there is no radiation protection, and further handling becomes very difficult.

★If cask water is lost, fuel cooling becomes impossible, but it is 3-years after the accident, and the decay heat is very small. It is 0.005% of the rated power. Total heat of 22 fuel assemblies is only 5KW (4500KWt-rated x 0.005% x 22Asy = 5KWt). So, meltdown in the cask does not happen.

★Even if all fuel pellets fall down to the bottom of the cask, it will not reach critical, because there is no appropriate arrangement between fuel rod and water for neutron moderation.

★ Cask drop accident is common to any plants, and not specific to F-4. All BWRs in the world have been practicing transportation of the cask from spent fuel pool to outside the reactor building. As far as I know, the world has never experienced cask drop accident.

3) Possible damage on fuel

When hydrogen explosion occurred at F-4, concrete debris and iron fragments fell down on the spent fuel pool. TEPCO removed big fragments, but not enough. If small fragments of concrete exist between fuel assembly and fuel rack of the pool, it may become impossible to remove fuel assembly from the pool. Most of fuel assemblies are covered with channel box (made of zirconium), and they will be OK. But, some of them may not be covered with channel box. If these fuels are compulsorily removed in this situation, we have to allow some radioactivity release, because fuel cladding will suffer some damage. This is not happy, but its risk is limited.

Yoshioka's conclusion:

Yes, fuel transportation from F-4 has some risk. But, even in worst case, meltdown will not occur. Also, re-critical accident will not occur.

The real risk is a drop accident of a transportation cask. If it happens, some radioactivity will be dispersed, but FP gas has already decreased, and dispersion is limited near the ground of F-4 reactor.

If we do not transport, fuels stay at the pool within the destroyed building, and it is more dangerous. So, fuel transportation from F4 pool can decrease the total risk.

Transportation process of F1/F3 spent fuel pool has just started, and it will take several years. We have to watch the progress.