The Radio Active Decays and Heat Emissions of the Candu Reactor's Used Fuel Bundles

A brief summarized presentation and review of the experimental data and mathematical calculations of the short-lived and long-lived fission products, actinides and activation products produced in one used fuel bundle.

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NUCLEAR SPONTANEOUS CRITICALITY

Is It A Possible Safety Hazard?

A team of nuclear scientists at the Los Alamos National Laboratory in New Mexico fear that burying nuclear waste at Yucca Mountain in Nevada could lead to a spontaneous atomic explosion, releasing radiation into the atmosphere and groundwater. According to their analysis, plutonium- 239 could escape from disposal canisters into the surrounding rock, which possesses physical properties (such as a combination of two elements ($_{90}Th^{228}$And $_{4}Be^{9}$),that might aid a spontaneous chain reaction and explosion. Another team of scientists at the Department of Energy facility at Savannah River have endorsed this thesis (1)

The mechanism of such nuclear spontaneous criticality is based on the following facts:

1- In each used fuel bundle there are 91.2 grams of fissile material (43.7 grams of U-235 and 47.5 grams of Pu-239).

2-The radioactive disintegrations' processes of the actinides elements inside the used bundle (such as $_{90}Th^{232}$, $_{92}U^{236}$, $_{92}U^{238}$, $_{94}Pu^{240}$, $_{94}Pu^{242}$, $_{95}Am^{241}$ etc) are sources of alpha particles, and one element of the short-lived fission products ($_{96}Cm^{242}$) is a source of neutrons.

Therefore a nuclear spontaneous criticality could be achieved if one atom of U-235 and/or Pu-239 absorbs one neutron or one alpha particle. The following are the possible reactions which represent the nuclear spontaneous criticality and fission chain reactions:

$$_{92}U^{235} + {}_{0}n^{1} \dashrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\ {}_{0}n^{1} + 200\ \text{Mev}$$

$$_{92}U^{235} + {}_{2}He^{4} \dashrightarrow {}_{58}Ce^{142} + {}_{36}Kr^{94} + 3\ {}_{0}n^{1} + 165\ \text{Mev}$$

$$_{94}Pu^{239} + {}_{0}n^{1} \dashrightarrow {}_{56}Ba^{142} + {}_{38}Sr^{95} + 3\ {}_{0}n^{1} + 198\ \text{Mev}$$

$$_{94}Pu^{239} + {}_{2}He^{4} \dashrightarrow {}_{60}Nd^{148} + {}_{36}Kr^{92} + 3\ {}_{0}n^{1} + 174\ \text{Mev}$$

(U=Uranium, Pu= Plutonium, He= Helium, Ce= Cerium, Kr= Krypton, Nd = Neodymium, Ba= Barium, Sr= Strontium)

Gordon Sims, a Canadian researcher , described an example of the spontaneous nuclear criticality in his book (The Anti- Nuclear Game). The following is his description:

"Several hundred million years ago in what is now GABON in West Africa, a rich Uranium deposit became nuclear reactive when water started to flow through it. The uranium in the deposit at that time had a higher abundance of uranium- 235 than is found today, and it began to fission(due to alpha absorption). That was a natural model of a water- moderated nuclear reactor. Plutonium- 239 was formed as a result of this natural nuclear reaction, and although it has long since decayed away, its daughter product are still found close to the parent material from which they were formed, despite the water flow (2).

CONCLUSION

It is a very well known scientific fact that a nuclear criticality occurs when sufficient quantities of fissionable materials come together in a precise manner and the required conditions exist to start and sustain a nuclear chain reaction.

The Dry Storage Container was designed to prevent a criticality from occurring inside the used fuel bundles. In addition, it is very unlikely that a sufficient quantity of fissionable materials could accumulate in the precise configuration and with the required conditions to initiate or create a criticality inside DSC. (3)

At my meeting with OPG designers of the DSC on August 27th 2004, I learned that an explosive spontaneous criticality inside DSC is not possible technically, and this opinion is supported totally by a continuous American experience for 15 years of safe Dry Storage Containers.

Finally I believe that the whole thesis of nuclear spontaneous criticality is strange and scary but it is totally unreliable. Therefore, I wonder if the Los Alamos lab and DOE teams are still holding their fear after 15 years of American experience with DSC without any indication of the so-called spontaneous criticality. This period of time is long enough to test and prove that this thesis is not credible.

References -

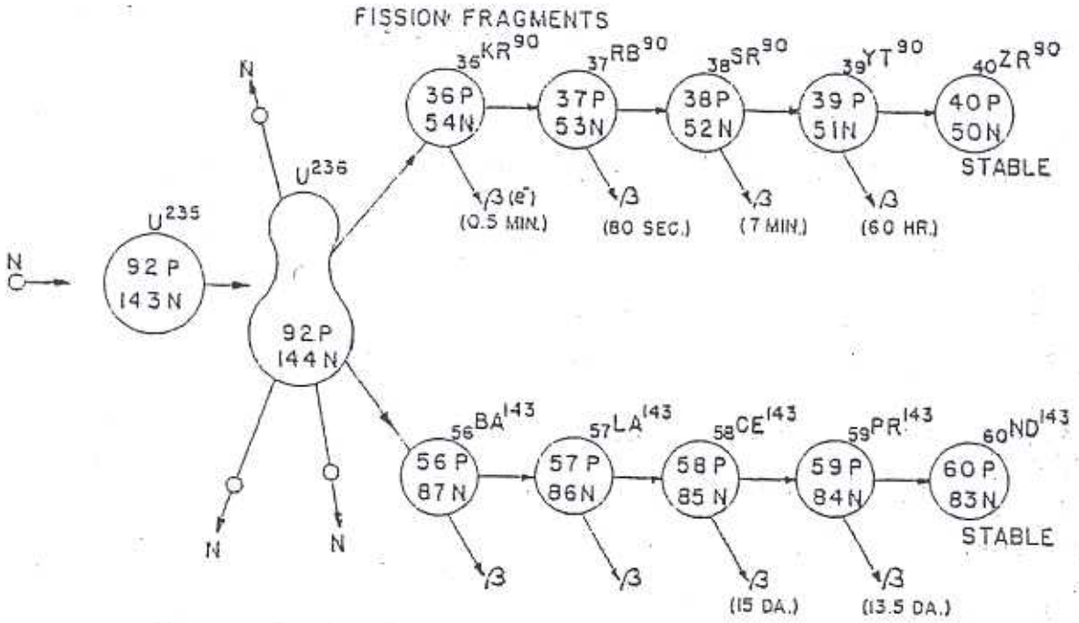
1. Harry Henderson- Nuclear Power, Santa Barbara, CA 2000. pg 108
2. Gordon Sims- The Anti-Nuclear Game, University of Ottawa, Ottawa 1990. pg 142
3. Harry Henderson- Nuclear Power, Santa Barbara, CA 2000. pg 101

A Comparative Table of the Constituent Elements in One Fuel Bundle, Fresh and Spent (19 kilograms)

Constituent Elements	Fresh Fuel		Spent Fuel	
	Grams	%	Grams	%
1) Uranium-238	18863.2	99.28	18492.7	97.33
2) Uranium-235	136.8	0.72	43.7	0.23
3) Short-lived Fission Products			97.73	0.513
4)Long-lived Fission Products			140.6	0.74
5) Actinides Products			122.93	0.647
6) Activation Products			102.34	0.54
Total	19,000.00	100	19,000.00	100

Heat Emission From Radioisotope Groups Produced In One Fuel Bundle

	a- At removal of hot bundle from reactor t = 0		b- After 5 years of bundle cooling in wet storage t = 5y	
Radioisotopes Groups	Calories/sec	%	Calories/sec	%
1. Short-lived Fission Products	257512	99.643	0.00	0.00
2. Long-lived Fission Products	716	0.277	716	77.57
3. Actinides Products	206.9	0.07	206.9	22.42
4. Activation Products	0.1	0.01	0.1	0..1
Total	258435 (100%)	100	923 (0.357%)	100



Representing the fission of uranium 235 plus neutron, forming two short radioactive "chains".