Hydrogen protects nuclear fuel in final storage

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By midsummer it will be announced where Sweden's spent nuclear fuel will be permanently stored. Ahead of the decision a debate is underway regarding how safe the method for final storage is, primarily in terms of the three barriers that are intended to keep radioactive material from leaking into the surrounding groundwater.

But according to the new doctoral dissertation, uranium would not be dissolved by the water even if all three barriers were compromised.

"This is a result of what we call the hydrogen effect," says Patrik Fors, who will defend his thesis in nuclear chemistry at Chalmers on Friday. "The hydrogen effect was discovered in 2000. It's a powerful effect that was not factored in when plans for permanent storage began to be forged, and now I have shown that it's even more powerful than was previously thought."

The hydrogen effect is predicated on the existence of large amounts of iron in connection with the nuclear fuel. In the Swedish method for final storage, the first barrier consists of a copper capsule that is reinforced with iron. The second barrier is a buffer of bentonite clay, and the third is 500 meters of granite bedrock. Some other countries have chosen to make the first barrier entirely of iron.

It is known that microorganisms and fissure minerals in the rock will consume all the oxygen in the groundwater. If all three barriers were to be damaged, the iron in the capsule would therefore be anaerobically

corroded by the water, producing large amounts of hydrogen. In final storage at a depth of 500 meters, a pressure of at least 5 megapascals of hydrogen would be created.

Patrik Fors has now created these conditions in the laboratory and examined three different types of spent nuclear fuel. All of the trials showed that the hydrogen protects the fuel from being dissolved in the water, even though the highly radioactive fuels create a corrosive environment in the water as a result of their radiation. The reason for the protective effect is that the hydrogen prevents the uranium from oxidizing and converting to liquid form.

Furthermore, the hydrogen makes the oxidized uranium that already exists as a liquid in the water shift to a solid state. The outcome was that the amount of uranium found dissolved in the water, after experiments lasting several years, was lower than the natural levels in Swedish groundwater.

"The hydrogen effect will prevent the dissolution of nuclear fuel until the fuel's radioactivity is so low that it need no longer be considered a hazard," says Patrik Fors. The amount of iron in the capsules is so great that it would produce sufficient hydrogen to protect the fuel for tens of thousands of years.

Patrik Fors carried out his experiments at the Institute for Transuranium Elements in Karlsruhe, Germany, in a joint project with Chalmers. The institute is operated by the European Commission. The research was also funded by SKB, the Swedish Nuclear Fuel and Waste Management Company.

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