Nuclear Energy

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Safety Aspects

Fuel used

The fuel in a thermal reactor depends on the exact specifications of the reactor. They are often pellets of uranium (IV) oxide, enriched to about 3%, and in ceramic form. These pellets are placed in a narrow hollow tube, made of zirconium or magnesium. (These tubes are narrow to allow the neutron to escape to be moderated).

After a few years, the fuel rod does not contain enough U-235 (depleted uranium) and will no longer support a chain reaction. It has to be replaced by new fuel.

The fuel elements contain highly radioactive substances from the fission products, and so are removed remotely. They are still generating heat from the radioactive decay, and so are stored for a time in *cooling ponds*. Many of the decay products have short half-lives and so their activity is reduced considerably by the time the fuel is removed from the pond.

Thereafter fuel is remotely removed from its cladding, and is dissolved in nitric acid and an organic solvent. It is allowed to settle in a separating tank.

The following are removed:

- Uranium, to be reprocessed for re-use.
- Plutonium, to be used in other reactors, and weapons
- Fission products—the main component of high-level active nuclear waste—which have to be stored indefinitely.

Shielding

There is a great deal of radiation produced in the reactor, so it is essential that personnel are protected by shielding. α and β radiation both have limited range and are easily stopped, but the γ rays and neutrons are very penetrating. To stop these, thick concrete shields (5 m) are placed around the reactor. The core also has an inner casing of steel, as a pressure vessel, designed mostly to stop the escape of any radioactive gases.

Emergency shut-down

The fission process can be stopped very quickly by inserting the controls rods fully into the reactor. They are suspended electromagnetically, so that in the event of power failure they simply drop. This action reduces the energy produced, but it cannot stop the heat produced by the decay of the fission products. The cooling system needs to continue to operate to take this energy out. If this fails, the heat produced will melt this core (melt-down). This has potentially disastrous effects, as the shielding may collapse and release the radioactive substances. In the event of coolant loss, there are huge supplies of water available to keeping flooding the core.

Whatever goes wrong, it is not possible for a nuclear reactor to explode like a nuclear weapon.

Production, handling and disposal of active wastes

Radioactive waste is placed into one of three categories, depending on the amount of radiation that is produced.

Low level waste

This is material that is only slightly radioactive, such as protective clothing, and instruments that have been in contact with radioactive substances. Cooling water is also classified as low level.

It is stored inside steel containers in large vaults. Cooling water is treated to remove radioactive substances and then released into the sea.

Intermediate level waste

This includes materials that have been subjected to quite intense radiation, such as reactor components, fuel cans, and liquid produced in treatment.

It is covered in concrete and placed in steel drums, which are placed underground.

High level waste

This includes fission fragments from reprocessed fuel, which are converted into a type of glass vitrification and stored in a carefully selected geological repository, possibly for thousands of years.