PLUTONIUM - QUESTIONS AND ANSWERS

What is plutonium?
When uranium is put into a nuclear reactor as a fuel, the resulting nuclear reactions create a large number of radioactive substances of which plutonium is one. Some of the other 40 radioactive substances created include caesium, ruthenium, iodine, krypton and strontium. Given its long radioactive half-life, some 24,000 years, once produced, plutonium remains a deadly environmental contaminant and a potential material for nuclear weapons for far longer than human civilisation has existed to date.

Plutonium does not occur naturally in the environment. The only background environmental sources of plutonium are from nuclear power production, nuclear weapons production and nuclear weapons testing.

Why is plutonium dangerous?
Plutonium has only existed in the environment since the first atomic bomb was detonated in the US in 1945. As a result very little is known about how plutonium behaves in the environment and in the human body. What is known is that plutonium is a highly radio-toxic element; inhalation of a single microgram, smaller than a speck of dust, can cause fatal lung cancer. There is no safe dose of exposure for humans. Plutonium once inside the human body will remain there for a very long period of time – longer than the average life of a person. Plutonium therefore stays within the body exposing very sensitive parts of the body to very damaging alpha radiation which can lead to genetic damage that can cause cancer or other health effects such as birth defects in offspring.

Why is plutonium used in nuclear weapons?
Plutonium is the most highly prized material for making nuclear weapons and has been an essential part in driving the nuclear arms race over the last half century. It was a U.S. plutonium bomb that was used kill over 50,000 people in the atomic bombing of the Japanese city of Nagasaki in 1945. The quantity of plutonium used to destroy Nagasaki, was 6.1 kg. The plutonium in the bomb had an explosive force of around 20 kilotons (20,000 tonnes of TNT equivalent).

The only reason governments researched nuclear energy during the 1940s and 1950s was to develop nuclear weapons. Although nuclear bombs can be made from highly enriched uranium, most of the countries with nuclear weapons have decided to use plutonium. This is because plutonium is more ‘nuclear reactive’ in its normal state. In other words it takes less energy to force the plutonium into a supercritical mass which leads to a runaway nuclear chain reaction that explodes into a nuclear fireball. This means that a plutonium bomb can be made much smaller than a uranium bomb and therefore is suitable for putting into a missile - most modern intercontinental ballistic missiles carry up to ten plutonium bombs (called warheads) in their nose cone.

Plutonium can be made very pure for nuclear weapons. As the level of impurities in the plutonium decreases the explosive force can be increased. This pure form of plutonium is called ‘weapons grade’. However even plutonium that has relatively high levels of impurities, such as that used in nuclear power stations, can be used as a nuclear explosive. Such a ‘reactor grade’ plutonium bomb was successfully detonated in 1962 as part of the U.S. nuclear weapons testing program.

How do they get plutonium out of the nuclear reactor?
Once the irradiated uranium fuel rods in a nuclear reactor reach the end of their useful life (usually around three years) the fuel is unloaded and treated as highly radioactive nuclear waste. The waste nuclear fuel (called spent fuel) is so radioactive that it generates a large amount of

heat and needs constant cooling – this is usually done by submerging the waste fuel rods in huge ponds of water at nuclear power stations.

Some countries with nuclear power have decided to use a nuclear process to extract the plutonium from the spent fuel rods. This process is called nuclear reprocessing. Nuclear reprocessing is crucial to produce plutonium for nuclear weapons - all the countries with plutonium based nuclear weapons have reprocessing facilities.

What is nuclear reprocessing?
The process of reprocessing is carried out at very large reprocessing facilities. Reprocessing is quite a simple operation. Once the spent nuclear fuel rods have cooled a little, after about one to three years, the rods are cut into pieces using a giant chopping machine – this releases all the radioactive gases stored inside the metal fuel rods and most of these radioactive gases are discharged into the atmosphere.

From the chopping machine the pieces of spent fuel rods are tipped into a large steel vat of boiling nitric acid. Here the nitric acid dissolves the nuclear fuel, but leaves the metal pieces of the rods intact. This mixture is then sieved to take out the metal pieces of rods and this is stored as intermediate nuclear waste – this waste is still extremely radioactive and requires looking after for thousands of years. The remaining liquid nuclear waste is then pumped through a large number of chemical processes that use solvents to slowly extract out the plutonium and uranium from the liquid mixture. The remaining liquid waste is still extremely radioactive and gives off huge amounts of heat and requires constant cooling.

Nuclear reprocessing creates a huge amount of waste from all the machinery, buildings, liquids and chemicals used, filters, clothing of the nuclear workers, etc. As a result reprocessing creates up to 180 times more nuclear waste as compared to the volume of the original spent nuclear fuel.

The resulting high-level liquid waste, that requires constant cooling, still contains as much radioactivity in it as the original spent fuel – reprocessing does not reduce the radioactivity of the waste. In fact reprocessing makes dealing with nuclear waste much more difficult and expensive to manage - because instead of the solid spent fuel, reprocessing creates countless forms of contaminated liquids and chemicals, leftover solid wastes, machinery and buildings as well as the radioactive gases and liquids released into the atmosphere.

At all nuclear reprocessing facilities the resulting low level liquid wastes are discharged into rivers or the sea via pipelines. The radioactive gases are released into the atmosphere through chimneys. The two largest reprocessing facilities in Europe, Sellafield in northern Britain and La Hague, in northern France have some of the world's highest radioactive liquid and gaseous waste discharges into the sea and atmosphere. These two nuclear facilities account for over 97% of all the liquid radioactive discharges into the environment from all nuclear facilities in Europe. Nuclear reprocessing is an environmental disaster.

What is plutonium MOX fuel?
MOX fuel stands for Mixed Oxide fuel. This means that both plutonium and uranium are mixed into a nuclear fuel. The plutonium content of the MOX fuel varies from 3% up to 10 % of the total weight. The plutonium used is usually from the reprocessing operations. However the uranium used is usually freshly mined uranium and not the uranium recovered by reprocessing. This is because the reprocessed uranium is still contaminated with small amounts of radioactive waste and therefore many nuclear power companies do not want to use it in their reactors.

The uranium and plutonium are mixed together as a powder and then turned into a ceramic fuel pellet measuring about 2cm high by 1cm wide. These MOX pellets are then loaded one on top of the other into long fuel 'pins'. These fuel pins are made of hollow metal tubes and can be up to 3 metres long. Usually there are some 300 fuel pellets in each fuel pin. Each MOX fuel pin is then placed with others in a fuel 'assembly' that has around 289 pins in total (17 pins high and 17 pins wide). This finished MOX fuel assembly is what is finally loaded into the nuclear reactor.

What's the problem with MOX fuel?
Most nuclear power stations were designed and built to use only uranium fuel. When plutonium MOX fuel is placed in the reactor instead, the whole safety of the reactor is reduced. This is because plutonium is more 'reactive' – which is why nuclear bomb makers like it. This increase in 'reactivity' inside the nuclear reactor is more than the original reactor designs allowed for. This means that additional measures and modifications are required to the reactor, thereby increasing the risk of accidents.

The plutonium MOX fuel becomes hotter and more radioactive than the normal uranium fuel and this can lead to the reactor safety margins being reduced. Therefore in any type of loss of coolant accident, (this is one of the worst types of reactor accident and similar to the 1979 Three Mile Island Accident in the USA), means that the hotter, more radioactive MOX fuel can cause increased localized melting of the fuel in the reactor. This melting in the reactor's core can spread to other fuel in the core and start the catastrophic 'meltdown' accident as at Three Mile Island nuclear power station.

Further safety concerns about using MOX have been exposed following recent scandals in Japan concerning the deliberate falsification of crucial safety data in MOX fuel delivered to Japan in October 1999 that was manufactured by British Nuclear Fuel Ltd (BNFL) at Sellafield. The falsification by BNFL related to measurements made of the diameter of the MOX fuel pellets. This data is crucial because any pellets that are too large or too small should be rejected and not put into the MOX fuel assemblies. This is because once inside the reactor, the wrong sized pellets can vibrate or expand and rupture the metal fuel pins, releasing radioactivity into the reactor and increasing the risk of a meltdown accident.

As well as causing safety problems in the reactor, plutonium MOX fuel leads to increased hazards for the workers involved in making the fuel. The plutonium gives off more radiation than the uranium and therefore increases the radiation exposure to workers. Also once the MOX fuel is finished in a nuclear reactor, it is much more radioactive and hotter than normal spent nuclear fuel – this greatly exacerbates the already severe problems of dealing with highly radioactive spent nuclear fuel. Spent plutonium MOX fuel is also very difficult to reprocess – there are no commercial reprocessing facilities operating in the world that reprocess spent MOX fuel.

Is transporting MOX fuel safe?
The release a small amount of the plutonium in MOX fuel as a result of an accident during transport could lead to widespread environmental, health and economic impacts for the surrounding area.

The containers used for transporting the plutonium MOX fuel to Japan by ship are only tested to a fire of 800 degrees centigrade for 30 minutes. According to worldwide statistics the average fire on ships burn for 23 hours at higher temperatures. In these types of fires, past experiments have shown that the containers will breach. Tests on plutonium MOX fuel exposed to air has shown that it can start to be broken down within 15 minutes in temperatures of only 430 degrees centigrade. Once the plutonium fuel starts to break up, breathable sized particles of plutonium can escape into the air and can be blown far from the scene of the accident depending upon the weather conditions. Such plutonium particles would be a very serious health hazard to anyone who breathed them in. Once in the environment the plutonium particles would contaminate a large area for many hundreds of years, with devastating consequences for the health and livelihoods of the local people affected.

Is MOX fuel economic?
No. The average cost of manufacturing MOX fuel is between 3 – 8 times more expensive than normal uranium fuel. This is because the radiation exposure to the workers making the fuel has to be reduced and this leads to many cost increases.

Why does Japan want MOX fuel?

The Japanese government and its nuclear industry did not originally want plutonium MOX fuel. In the 1970s Japan started to realise that its increasing number of nuclear reactors did not have any way of dealing with the large amounts of spent nuclear fuel being unloaded from the reactors. As in most other countries with nuclear power, public opinion and support for the industry has always dropped when the unsolved issue of nuclear waste needs to be addressed. The Japanese industry and government wanted to find a way to reduce the opposition to the unsolved nuclear waste problem. Sending large quantities of Japan's nuclear spent fuel to the reprocessing facilities at Sellafield in Britain and La Hague in France, became the easiest way to deal with the problem in Japan.

The contracts Japanese nuclear power station operators signed in the 1970s with Britain and France required that the plutonium and some of the resulting wastes from reprocessing should be taken back to Japan. To date Japan has some 30 tonnes of plutonium separated out of its spent nuclear fuel in the two European reprocessing facilities. A further 15 tonnes of plutonium will become separated within the next ten years at these reprocessing facilities.

The Japanese nuclear industry and government decided to try and use any returned plutonium in a new type of nuclear reactor called a Fast Breeder Reactor. This reactor uses mainly plutonium instead of uranium as a fuel. However, Fast Breeder Reactors have been a technological failure around the world, with countries such as Britain, USA, France and Germany abandoning their Fast Breeder Reactor programs due to technical and economic problems. Japan's own large scale Fast Breeder Reactor called Monju, was opened in 1994 and only operated for 18 months before suffering a major coolant leak of liquid sodium. The reactor has remained closed ever since.

With no credible use for the plutonium planned to be shipped back from Europe and increasing opposition from the countries along the transport routes, the Japanese nuclear industry and government tried to find a replacement use for the stockpiled plutonium. It was in 1997 that the Japanese government announced that plutonium in Europe would be made into plutonium MOX fuel for use in normal Japanese nuclear reactors.

In the last 15 years two large shipments of plutonium have been completed from Europe to Japan. The first in 1992 transported 1.7 tonnes of plutonium in the form of plutonium oxide powder. Due to the strong opposition from 60 countries along the shipment routes, no further shipments of plutonium oxide were made. In 1999 the first shipment of plutonium to Japan in the form of plutonium MOX fuel took place. This controversial shipment met with strong international opposition from the countries along the transport route. The shipment ended in a huge scandal over the deliberate falsification of the MOX fuel's crucial safety data. The MOX fuel delivered to Japan in 1999 has not been put into any Japanese nuclear reactors because of the falsification scandal.

At the beginning of 2001 the second plutonium MOX fuel shipment to Japan departed from France. This MOX fuel shipment is already controversial because further evidence of safety data falsification of the MOX fuel in transit, is now being revealed. In the last 15 years, the Japanese government and nuclear industry have managed to transport around 2,100 kg of weapons usable plutonium to Japan from Europe.

None of this plutonium in Japan has been used to generate electricity and it remains stockpiled. Japan's program of acquiring and stockpiling plutonium, the largest outside the official nuclear weapons states, is of proliferation concern and as a consequence is a significant contributor to regional tension in North-East Asia. Japan over the next ten years plans to transport as much as 45,000 kg of plutonium from Europe to Japan, in the form of MOX fuel; this will require up to 80 transports similar to the controversial 1999 plutonium MOX fuel shipment to Japan.