MARINET

Marine Implications of MAGNOX FED dissolution

What is MAGNOX FED.

The UK's first generation of nuclear reactors, the Magnox reactors, used uranium fuel clad in a magnesium oxide casing to generate energy. Fuel elements, about 1 metre long and 5 cms in diameter, were removed from the reactor when "spent" and sent for storage to the on- site "cooling ponds" while their radioactivity declined.

After about two years their external, magnesium oxide cladding components were removed (while the fuel was still in the ponds) prior to the spent uranium being shipped to Sellafield for reprocessing at the infamous Sellafield B205 Magnox reprocessing plant.

However, the removed components, known as Fuel Element Debris or FED, consisting of magnox alloy "splitter blades", locating "lugs", + non magnesium oxide components such as thermo couple wires and nimonic springs, were retained at the various MAGNOX reactor sites and stored (wet or dry) in concrete vaults which may have been above or below ground, depending on site. Since 1960, when the Magnox programme began, hundreds of tonnes of FED have been produced. This material is currently stored at the Magnox sites where the FED originated, all of which are owned and operated by Magnox Ltd.

The latest plans for dissolving FED waste are threefold.
At the Dungeness A Magnox site (Kent coast), a dissolution plant has been operating since the late 1980s, where the site's own FED has been dissolved using a relatively slow process which has recently been completed. It is proposed that Dungeness A will receive and process the FED waste from the Sizewell A Magnox station, though it is not entirely clear whether this will be carried out using the existing slow process or not.

At the Bradwell Nuclear Power Station (Essex coast) the implementation of FED dissolution is well advanced and the plant may soon be opened to dissolve the plant's own FED using a different dissolution process which is much faster (estimated that ALL Bradwell's FED will be dissolved in 18 months). Under current proposals Bradwell is expected to dissolve only it's own FED.

At Hinkley Point A (Somerset coast), it is proposed that the FED from the Magnox stations at both Oldbury and Hinkley will be dissolved using the faster 18 month process.

It is evident from the above that there will be significant (road and rail) numbers of transports of both "raw" FED and probably of the process generated Intermediate Level residues.

FED dissolution process

In the context of the final closure of all of the UK's Magnox reactors, the Nuclear Decommissioning Authority had decided that Intermediate Level Radioactive Wastes stored at the individual sites should be retrieved, processed and packaged for interim storage and eventual disposal.

However, more recent (post 2011) NDA statements have proposed a variation of the earlier position. It is now the NDA's view that

a: Magnox Ltd has an obligation to reduce the volume of waste stored for disposal,

b: Magnox has an obligation to deal with such waste in a manner that best ensures protection of the public and the environment

c: consolidation of facilities offers safety, environmental and economic benefits

In pursuit of the policy to reduce the volume of wastes at Magnox sites the NDA and MAGNOX have jointly set about a programme to expedite the dissolution of FED.

FED dissolution was first carried out at a plant built at the Dungeness A Magnox reactor site (Kent coast) in 1988. The Dungeness FED dissolution plant was described as a "lead demonstration" plant and used a carbonate dissolution process in which carbon dioxide was bubbled through water to create carbonic acid and dissolve the metal components.

The Dungeness plant Intermediate Level waste included about 3 tonnes of un-corroded fuel element debris and about 57 tonnes of "sludge" in separate ponds. The Dungeness storage ponds were not full in 1988 but the CEGB (then owners/operators of Magnox sites) decided to test the process at Dungeness because "accumulations of sludge and metallic debris were both available".

The CEGB confirmed that the process was intended to produce " a small volume of concentrated waste which can be better stored and monitored whilst awaiting a final disposal route" and that the process would also generate a large volume of low activity liquor which would have to be discharged to sea

In 1988 the CEGB insisted that the Intermediate Level Waste material to be processed could now be classified as low level waste because it had been given time to decay from it's original intermediate level classification.

The more recent proposals for FED dissolution seek to use nitric acid instead of the carbonic acid process. This has been adopted because of the faster speed of nitric acid dissolution (18 months) rather than the many years taken by the Dungeness carbonic acid system.

The first new FED dissolution plant is due to open very shortly at the Bradwell nuclear station on the sediment rich Blackwater estuary in Essex. It is proposed that FED shall be retrieved from its storage vaults and dissolved in Nitric Acid.

It has been stated that it is a "project assumption" that the Nimonic Springs (rich in highly radioactive Cobalt 60), fuel "fragments" (rich in transuranics), thermocouple wires etc "will be segregated prior to treatment and transport". However, to date, no fully detailed description of such a segregation process has been provided and whether the "project assumption" has yet become a regulatory requirement remains unconfirmed.

During the dissolution of the FED in nitric acid the process will generate highly radioactive wet solids. It is stated that "the bulk of the radioactivity will be retained within the residue and secondary wastes" which will be packaged in containers suitable for interim storage and eventual disposal. The dissolution process will also generate a less radioactive liquid which would be discharged to sea. It is stated that the liquid effluents from the plant will be sand-filtered prior to discharge and that this will suffice to remove any higher level particles and radioactivity.

To date Magnox Ltd have referenced the Dungeness FED plant as the "lead demonstration" plant but failed to discuss the similarities and dis-similarities between the two plants which are plainly using different technologies

a: nitric acid dissolution as opposed to the CO2 method,

b: many years to dissolve one station's FED (Dungeness) as opposed to possibly 2 stations worth of FED dissolved in 18 months (Magnox Ltd response to FoI request on nitric acid units)

Content of FED Dissolution liquid radwastes discharges to sea

In response to the lack of detailed information about the potential environmental outcomes of FED dissolution, the UK Nuclear Free Local Authorities (NFLA) submitted a complex FoI request to Magnox Ltd and after several months a response was received.

The Magnox Ltd response provided a *"List of expected constituent/individual radio nuclides in the proposed liquid discharge stream".* This list consists of 20 named radio nuclides including such nuclides of concern as Tritium, Cobalt 60 Strontium 90 and also the alpha radioactivity emitting transuranics such as 2 nuclides of Plutonium (Pu 240 and Pu 241) and one of Americium (Am 241).

The Magnox Ltd response to the NFLA's FoI request also offered a small table purporting to provide *"Estimated quantities of each consistent radio nuclide in the liquid waste stream"* of an FED plant. However (putting aside the contextually inexplicable use of the word "consistent") there were other anomalies/flaws in this table as follows:

a: it only actually named 2 radio nuclides : Tritium and Caesium 137.

b: **Cs 137 had NOT been named in the "List of expected constituent/individual radio nuclides" :** so it's appearance in the table of "Estimated quantities" remains un-explained and unjustified and directly contradicts the Magnox Ltd responses 20 strong "list of expected constituent/individual radio nuclides…."

c: the remaining 19 (un-named) nuclides were simply classified as "other" and their estimated quantities aggregated into one figure, a policy which has successfully avoided providing specific detail on the volume of Pu 240, Pu 241 and Am 241.

Increased discharges of radioactivity due to FED dissolution.

Tritium:

The Magnox FoI response stated that the predicted, actual discharges of Tritium to sea would be around 6.55 TBq (1 TBq = 1 trillion Bq=1,000,000,000,000 Bqs). On this basis, at the proposed Bradwell FED dissolution site, annual discharges of Tritium will be about 260 times higher than the current discharges from the reactor site, and ten times higher than discharges prior to the closure of the reactors (as reported in annual RIFE monitoring reports). This represents significant elevations of

discharges of tritium, which since the later 1990s has increasingly been shown to be of far greater public health radiological significance than had previously been thought.

Despite the growing body of academic and independent (non nuclear industry/non government regulators) reporting of the evidence of potential environmental and human health impacts of tritium nothing can be done to reduce the discharges because there is simply no functional tritium abatement/reduction process. This is why ALL UK nuclear new build (reactors, FED plants etc) inevitably entail proposals to release large quantities of tritium atmospherically (through stacks and chimneys) and to sea via pipelines.

Alpha emitting transuranics

Another issue of particular concern is the fact that FED will have been substantially contaminated with a broad range of alpha emitting transuranic radio nuclides such as Plutonium, Americium and Curium. The degree of such contamination has not yet been quantified.

It is well known that Magnox fuel elements have, in the past, suffered from the problem of "tramp" Uranium arising on the exterior/interior surfaces of Magnox alloy fuel cladding as a result of flaws/weaknesses in the magnesium oxide cladding. Such flaws have been identified as occurring during both manufacture of new fuel elements and during (wet or dry) storage of used elements. Additional "tramp" uranium contamination of fuel element cladding may occur as a result of physical contamination of otherwise undamaged cladding during the manufacturing process.

Magnox Ltd has confirmed that, during the process of "de-splitting" or removing the magnesium oxide cladding from the fuel elements while still in the cooling ponds, the fuel elements themselves may have been damaged and hence pieces of fuel may be broken off the elements and transferred to the FED storage vault along with the FED debris.

As a result of irradiation during nuclear fission such tramp uranium generates a number of fission products including the transuranics and others, this material will then contaminate the magnox cladding prior to its removal for storage.

Additionally, if, during storage in vaults, used fuel should develop fuel pin and cladding weaknesses it is to be expected that a similar range of fission products originating from the uranium based fuel will also be produced and contaminate the magnox cladding and the associated fuel pin cladding debris.

In this context it is highly relevant to note that, at the Dungeness nuclear site, the marine monitoring programme changed dramatically when the Dungeness FED dissolution plant began work in 1988. Prior to that year there had been no regular reporting/analysis of alpha radioactivity emitting, transuranic nuclides in the Dungeness marine environment.

Following the commissioning of the Dungeness Magnox FED dissolution plant a regular programme of monitoring for transuranic alpha emitters has been reported in the annual monitoring reports (originally the MAFF AEMRs and, since 1995, the annual RIFE reports).

This analysis has been carried out since 1988 for three Plutonium nuclides (Pu238, Pu 239 and Pu 240), 3 Curium nuclides (Cm 242, Cm 243, and Cm 244) and one nuclide of Americium (Am 241).

The Dungeness site is a-typical of the UK reactor sites since it is one of relatively few UK reactors sites built on a headland projecting into relatively deep water, with a generally coarse sediment, adjacent inter tidal and coastal environment not well suited to the re-concentration of transuranic nuclides.

The annual AEMR and RIFE monitoring reports record the fact that the nearest and most regularly monitored marine inter tidal sediments are sampled at Rye Harbour and are described as sand and mud. This generally describes a relative coarse inter tidal sediment, not characteristic of those where the highest re-concentration of sea discharged transuranics is known to occur

However, even at the a-typical Dungeness site, where FED dissolution has proceeded at a very slow rate over many years (compared to the 18 month cycles proposed for the current FED dissolution plants such as Bradwell), there is some evidence to indicate that concentrations of the 7 transuranics have increased since 1988.

In contrast to the Dungeness site, the other proposed UK FED dissolution plants, Bradwell on the Blackwater Estuary and Hinkley Point in the Bristol Channel, are immediately adjacent to very large areas of coastal, inter tidal and sub tidal fine sediment deposits such as estuaries, salt marsh and mudflats where alpha emitting transuranics are widely known to re-concentrate to very high levels relative to their concentrations in ambient sea water. At sites such as these, any additional discharge of Plutonium, Curium and Americium would be expected to give rise to high enrichment factors of transuranics in regional fine sediments, with the finest sediments holding highest concentrations.

A further concern is the proposed discharge of Plutonium 241, which decays to produce the much more intensely radioactive Americium 241 with a much longer half life.

The failure of Magnox Ltd to provide any data about the quantities of Plutonium, Curium and Americium they expect their FED dissolution plants to discharge is a matter of deep concern which plainly militates against any serious scientific assessment of the environmental and public health impacts of the proposal.

In the context of the developing understanding of the potential impacts of marine discharges of Tritium (enormous bio-accumulation and enrichment factors through certain marine, inter tidal and coastal food chains) the proposed massive increase in tritium discharges from such sites has not been addressed by Magnox Ltd or by the NDA with the gravity it deserves.

In the context that the Nitric Acid FED Dissolution process is
a: similar in some respect to some of the historically un-reliable reprocessing activities at Sellafield

b: offers the prospect of 250 times + increases in the discharge of radioactive tritium
c: offers the prospect of increased discharges (and subsequent rising environmental concentrations) of long lived highly radioactive nuclides of Plutonium, Curium and Americium
d: characterised by a range of as yet uncertain parameters (how much transuranic contamination of FED? Lack of Environmental Impact Assessment. Et al')
e: will generate multiple road and rail transports of Intermediate Level Wastes : thus breaching elements of the Proximity Principle…which says that exposure of the public (including by transports) should be kept to the minimum

it is strongly advised that all new FED Dissolution proposals should be subject to fully detailed Environmental Impact Assessments and Public Inquiries into their Public Health and Environmental Implications.

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