Nuclear Free Local Authorities

new nuclear monitor

Number 22, December 2010

Concerns over aquatic radioactive discharges into the Irish Sea from proposed new nuclear reactors.

This paper has been developed for the NFLA by the independent marine pollution consultant, Tim Deere-Jones, following on from a presentation he gave to the NFLA All-Ireland Forum meeting in Swords, Fingal in late October 2010. The NFLA believe this presentation raises a number of key concerns from the UK's proposed new nuclear reactor programme, particularly in the area of discharges into the marine environment.

This edition of New Nuclear Monitor should also be read in conjunction with NFLA Policy Briefing 77, which considers potential increases in aquatic radioactive discharges and how this may infringe international commitments given by the UK under the OSPAR Treaty.

1. Introduction

Having announced its intention to support the construction of a new generation of nuclear power stations, the UK Government has now released its final list of 8 sites where development will be permitted. In accord with previous UK policy, all 8 sites are on the coast and will make aquatic radioactive discharges to the sea.

Three of these sites are situated on the east coast of the UK with any potential discharges into the North Sea, but the remaining 5 are on the UK's west coast with their potential discharges into the Irish Sea.

2. Proposed Irish Sea reactors

The proposed Irish Sea stations will all be constructed at sites previously used for nuclear power generation.

Two reactors have already been proposed for Hinkley Point on the north coast of Somerset and a further two reactors for Oldbury on the Severn estuary in Gloucestershire. Discharges from these four reactors will initially enter the Bristol Channel. However, there is a general consensus that oceanic water enters the Bristol Channel along the north Devon and Somerset coast and that the Bristol Channel water subsequently discharges into the Irish Sea after running along the south Wales coast. This water then trends northwards through the Irish Sea.

Two or three reactors are proposed for the Wylfa site on the island of Anglesey off the north coast of Wales. This site will discharge into the western area of Liverpool Bay.

The remaining two sites are Heysham on the Lancashire coast, which discharges to the Morecambe Bay, and Sellafield on the Cumbrian coast. At the time of the preparation of this briefing, the number of reactors at Heysham and Sellafield has not been confirmed.

Nuclear Free Local Authorities Secretariat, c/o PO Box 532, Manchester, M60 2LA
Tel: 0161 234 3244 Fax: 0161 234 3379
Email: s.morris4@manchester.gov.uk Website: http://www.nuclearpolicy.info

A number of independent consultants continue to assert that that there is still a lack of systematic long-term data collection in almost all areas of the Irish Sea and that the circulation and water body movement in the North East basin of the Irish Sea is still a matter for in-depth discussion. However, it does appear clear that the Irish Sea water body movements will eventually combine the discharges from the potential ten new nuclear reactors; and the evidence of monitoring from the east coast of Ireland demonstrates that existing radioactive wastes discharged from these sites can reach the Irish coast.

The new reactors proposed for the Irish Sea coastal sites will be pressurised water reactors (PWR's) using uranium fuels (enriched to approximately 5% with uranium 235) to produce steam which will drive turbines generating electricity.

Under its Generic Design Assessment (GDA) process, carried out by the Environment Agency, the UK Government is considering licensing the construction of 2 types of pressurised water reactors: ***the EPR design***, developed by the French company Areva; ***and the AP1000 design***, developed by the American company Westinghouse. The manufacturers of both reactors have stated that the expected service life of their reactor will be ***at least 60 years.***

At the time of writing this briefing the final choice of reactors across the proposed sites has not been finalised. However, it appears that at Hinkley Point the developers (EDF) would prefer to develop 2 new EPR reactors. It appears from the EDF / Areva submissions that their proposed stations will have 2 reactors. However, the Westinghouse submissions imply that their preferred option will be three reactors per site.

3. Proposed liquid discharges from UK reactors

The proposed EPR reactors being developed for the UK are expected to generate liquid radioactive wastes consisting of a 'cocktail' of 14 named radionuclides and an indeterminate number of "others".

The GDA lists the major components of the liquid discharges as:

- Tritium
- Caesium 137
- Carbon 14
- Various (but un-defined) isotopes of Iodine, and Cobalt 60

The minor components of the liquid discharges consist of the following isotopes (isotopes are different forms of the specified element):

- Ag (silver) 110,
- Co (cobalt) 58,
- Cs (caesium) 134,
- Mn (manganese) 54,
- Sb (antimony) 124,
- Sb (antimony) 125,
- Te (tellurium) 123m,
- Ni (nickel) 63,
- Cr (chromium) 51
- and a number of un-named "others" which appear to include alpha emitting actinides which may include *isotopes of plutonium, americium, curium and uranium.*

N.B. EPR reactors are also expected to make atmospheric discharges of gases and particulates (via various stacks and chimneys) of Tritium, 3 named isotopes of Iodine, Cobalt 58, Cobalt 60, Caesium 134, Caesium 137 and 5 noble gases

The AP100 reactors are expected to generate liquid radioactive wastes consisting of a large number of radionuclides.

Table 3.4-6 of the AP1000 European Design Control Document and the Environment Report lists a total of 65 nuclides, including 3 isotopes of Uranium, 5 isotopes of Plutonium, 2 isotopes of Americium and 2 of Curium.

The GDA lists the major components of the liquid discharges as:

- Tritium
- Carbon 14
- Cobalt 60
- Caesium 137.

N.B.: The AP1000 reactors are also expected to make atmospheric discharges of gases and particulates (via various stacks, chimneys) similar to those from the UK EPR.

4. **Aquatic tritium discharge**

Tritium half life = 12 years

Source: primary and secondary reactor coolant waters (the volume of Tritium production relates directly to the rate of power production). Additional inputs of Tritium to the marine environment will derive from fall out and wash out due to a range of meteorological conditions such as rainfall, temperature inversion etc.

If the five new Irish Sea stations (or up to 10 possible reactors) make use of the EPR design the aggregated "expected liquid discharge" of Tritium (with no allowance for "contingencies") will be 520 TBq (520 million, million Bequerels) per year.

EDF and AREVA, the manufacturers and proposers of the UK EPR have asked for an annual liquid disposal limit for Tritium of 75 Tbq per reactor.

The UK Environment Agency's has granted this request and consequently the proposed annual limit for liquid Tritium discharges, aggregated for the 10 potential UK EPR reactors, is 750 TBq per year (750 million million Bequerels.)

Westinghouse have predicted that the highest likely discharges of tritium from the ap1000 reactor will be 35.09 TBq per year (35 million, 90 thousand million Bq per year). If the five new Irish Sea stations (or up to 10 possible reactors) make use of the AP1000 the aggregated "expected liquid discharge" of Tritium (with no allowance for contingencies) will be 526.35 TBq (526 million, 350 thousand million bequerels) per year.

Westinghouse, the manufacturers and proposers of the AP1000 reactor have asked for an annual liquid disposal limit for Tritium of 60 TBq per reactor.

The UK Environment Agency's has granted this request and consequently the proposed annual limit for total liquid tritium discharges, aggregated for the 15 potential AP1000 reactors, is 900 TBq (900 million, million bequerels).

N.B.: Both requests for annual limits of Tritium discharge have been granted in full. The limits for the two different station types differ by **15** TBq per year (**15** million, million bequerels).

No explanation is given by the Environment Agency for the wide variation in limits. In the absence of such an explanation it may be surmised that the two widely varied limits are based on the demands/requests of the reactor manufacturers.

5. **Evolving understanding of the behaviour of Tritium in the marine environment**

Since the year 2000 ongoing research is producing data that challenges the earlier understanding of Tritium's environmental behaviour. This research shows that Tritium:

- rapidly associates with organic materials and suspended sediment particles
- shows elevated concentrations in sedimentary deposits
- has significantly greater interactions within the environment than previously predicted
- rapidly incorporates into marine organisms (fats and carbohydrates)
- sediment associated bottom feeding species show the highest concentrations
- which in turn generate higher than predicted dietary doses (up to 36 micro Sv) in Bristol Channel seafood critical groups.

Academic research* now implies that:

- current IAEA thinking on the behaviour and significance of tritium "may require reconsideration"
- the view that Tritium "dissolves to infinity" should now be "considered cautiously"
- mobilisation and transport of tritiated sediments is very poorly understood.

** Sources:*
"Distribution of Tritium in estuarine waters: the role of organic matter": Oct 2009 Journal of Environmental Radioactivity volume 100.
"An overview pf Tritium Behaviour in the Severn estuary" Journal of Radiological Protection Volume 21. 2001.
"Organically Bound Tritium (OBT) dispersion and accumulation in Severn Estuary sediments": Food Standards Agency Report R.O 1034.

It is uncertain whether the Environment Agency GDA has taken account of this evolving understanding of the behaviour and significance of Tritium.

6. **Carbon 14 aquatic discharges**

Carbon 14 Half life= 5,710 years

Source: Carbon 14 enters the marine environment in aquatic discharges and also via fall-out and wash-out from gaseous/atmospheric discharges.

Carbon 14 assimilates well into marine primary producers such as plants and plankton. C14 transfers up the food chain to higher trophic levels such as fish, mammals and human end consumers. Doses to humans mat occur via ingestion and inhalation. The GDA says initial dos rates to humans may be comparable to those received from tritium. Furthermore, due to its long half life, C14 has a relatively high potential for accumulating in the environment, especially in association with organic materials such as organic based silt and sediment deposits

EDF and AREVA, the manufacturers of the UK EPR have proposed no specific technique for the reduction of C14 in the liquid waste discharges. The Environment Agency has accepted the EDF / Areva position.

If the five new Irish Sea stations (10 new reactors) make use of the UK EPR the aggregated "expected liquid discharge" of Carbon 14 (with no allowance for "contingencies") will be 0.023 TBq (23 thousand million Bequerels) per year.

EDF and AREVA, the manufacturers and proposers of the UK EPR have asked for an annual liquid disposal limit for Carbon 14 of 0.095 TBq per 10 reactors (95 thousand, million bequerels per year.).

The UK Environment Agency has granted this request and consequently the proposed annual limit for C14 in liquid discharges, aggregated for the 10 potential UK EPR reactors, is 0.095 TBq per year (95 thousand, million Bequerels.)

The GDA's reporting of Westinghouse and Toshiba deliberations on the C14 discharges from the AP1000 is unclear and, as a result is not reported here.

However it does appear that, if the five new Irish Sea stations (as many as 15 reactors?) make use of the AP1000, the aggregated annual average "expected liquid discharge" will be 66 thousand, 300 million Bequerels per year.

What is certain is that Westinghouse Toshiba has asked for an annual discharge limit of 0.007 TBq (7 thousand million Bequerels) per reactor per year.

The UK Environment Agency has granted this request and consequently the annual limit for 15 potential reactors on the Irish Sea is 0.105 TBq (105 thousand million bequerels).

The UK Environment Agency has accepted two widely differing applications for annual limits for C14 in liquid discharges (95 thousand million Bequerels for the UK EPR and 105 thousand million Bequerels for the AP1000). Thus there is a 10 thousand million bequerel difference between the two limits.

The EA has not offered any discussion of the reasoning behind its preparedness to accept such widely varying proposed limits.

In the context of the EA's willingness to accede to the requests of both EDF/AEVA and those of Westinghouse/Toshiba it appears that these limits have been set in order to comply with the potential performance of each reactor rather than in order to comply with a common understanding of best environmental requirement or most limited environmental impact.

7. **Cobalt 60 aquatic discharges**

Cobalt 60 Half life = 5.27 years

Source: Cobalt 60 enters the discharge stream, in both dissolved and particulate form, as an activation product of stainless steel components found within the reactor and the cooling system.

Co60 is shown to concentrate in marine and estuarine sediments and in marine foodstuffs. It has been shown to mobilise in association with both the water column and mobile sedimentary particles.

EDF and AREVA have stated that they expect the annual discharge of Co60 (not including any "contingencies"), via pipelines and aggregated for ten reactors, will be 0.0018TBq per year or 1 thousand, 800 million Bq per year.

EDF and AREVA have proposed an annual discharge limit, aggregated for 10 reactors, of 0.015 TBq per year (15 thousand million Bq per year). The Environment Agency has accepted this proposal.

It can be calculated that Westinghouse / Toshiba expect the annual discharge of Co 60 (not including any contingencies) via pipelines and aggregated for 15 reactors will be 3 thousand, 450 million Bq per year.

Westinghouse/Toshiba have proposed an annual discharge limit (aggregated for 15 reactors) of 7 thousand 500 million Bequerels per year. The Environment Agency has accepted this proposal.

The Co 60 discharge limit for the UK EPR is 15 thousand million bequerels per year; the limit for the AP1000 is 7 thousand, 500 million bequerels per year. N.B.: The EPR limit will be twice that of the Westinghouse limit.

The EA has not offered any discussion of the reasoning behind its preparedness to accept such widely varying proposed limits.

In the context of the EA's willingness to accede to the requests of both EDF/AEVA and those of Westinghouse/Toshiba it appears that these limits have been set in order to comply with the *potential performance of each reactor rather than in order to comply with a common understanding of best environmental requirement or most limited environmental impact.*

It should be remembered that Cobalt 60 will also be a component of gaseous and atmospheric discharges leading to an unquantifiable amount of Co 60 entering the marine environment via wash out and fallout, dependent on ambient meteorological conditions.

8. **Discharges of other alpha emitters / actinides (plutonium, americium, curium and uranium)**

These substances are by-products of the use of uranium based fuels and many of their isotopes have very long half-lives. Many of the decay products of these isotopes also have very long half-lives. In the context of the postulated 60 year life spans for both the UK EPR and the AP1000 these alpha emitters and actinides may have a significant long term potential for concentration in the marine environment.

The Environment Agency's GDA says that these substances will only appear in the aquatic discharge stream as a result of problems with the fuel pins such as: surface contamination on the fuel pin cladding and/or impurities in the fuel cladding and perhaps the fuel.

Both manufacturers have stated that improvements in fuel design and manufacture will minimise these problems.

However the Environment Agency's GDA admits that the presence of various nuclides (e.g. Caesium 137) in the liquid effluent discharge streams of both proposed reactors are "an indicator of fuel cladding failure".

Evidently such problems are expected because Westinghouse/Toshiba has published a list (Table3.4-6 of the AP1000 European Design Control Document and the Environment Report) of 12 individual isotopes including:

- 3 isotopes of Uranium, 5 isotopes of Plutonium, 2 isotopes of Americium and 2 of Curium described as "expected annual release of radioactive effluent discharges"

EDF/AREVA also predicts that there will be discharges of various unspecified actinides and other alpha emitters.

Westinghouse have not provided any quantification for the discharges of 11 of their listed actinides (Plutonium 241 is the exception) restricting themselves to stating that the discharges of the 11individual isotopes are expected to be "negligible" and noting that the definition of negligible is "values less than 3.7E+4 Bq" (37,000 Bq per year)

9. **Plutonium 241 aquatic discharges**

Plutonium 241 Half-life = 14 years

Westinghouse have calculated Worst Case Plant Discharge (WPCD) for only one of the actinides (Pu 241) for the AP1000 reactor and concluded that it will be 178,000 Bq per year per reactor. Aggregated for 15 reactors this will be 2 million, 670 thousand Bq per year.

Westinghouse have proposed an annual limit for aquatic discharges of Pu 241 of 200,000 Bq per year (3 million Bq per year for the Irish Sea aggregated 15 reactors).

The Environment Agency's GDA estimates that the annual WCPD will be196,000 Bq per year per reactor and proposes no specific limit for Pu 241.

EDF/AREVA have failed to provide such a high degree of clarity and the Environment Agency's GDA consultation documents are only able to report that the discharge from the UK EPR will include a number of un-named “others” which appear to include alpha emitting actinides which may include unspecified isotopes of Plutonium, Americium, Curium and Uranium.

Both reactor manufacturers have stated that high removal efficiencies of coolant filtration will minimise actinide discharges and promise that alarmed alpha detectors will be installed at point of discharge. They also state that operational experience in other PWRs shows that no alpha emitters have been detected at point of discharge.

In the context of alpha emitters and actinides in liquid discharges, and on behalf of the NFLA, this author has submitted the following queries to the Environment Agency’s GDA process:

- what is the detection performance / threshold of the in-line detectors?
- what is the calculated quantity of alpha emitters for the UK EPR?
- what is the expected isotopic content of alpha emissions for the UK EPR?
- what are the sources of the expected alpha emitters?
- what factors might lead to the presence of detectable amounts of alpha?
- if / when the in-line detectors “detect” the presence of alpha emitters, what mechanisms will “prevent” the discharge of alpha emitters?

10. **Nuclear fuel manufacturing**

The proposed new build of nuclear power stations could give rise to at least 16 new reactors using enriched uranium fuels.

The UK Environment Agency has told the NFLA:

- that the generic Design Assessment process only concerns the “permitting” of the operation of the nuclear power plant.
- that “Uranium mining and fuel manufacture have not been considered under GDA”
- that “The companies have not been clear on manufacture of fuel as this will be a commercial decision made by the plant operator”.

There are two nuclear fuel factories sited on the Irish Sea coast.

Capenhurst (near Ellesmere Port) - has 3 units operated by Urenco UK Ltd and produces enriched Uranium fuels for nuclear power stations. The Capenhurst site makes aquatic discharges of tritium, uranium, uranium decay products, technetium and non-uranium alphas, to Liverpool Bay.

Springfields (near Preston) - in Lancashire also produces uranium fuels for a range of reactor types, including PWRs. Springfield Fuels Ltd is owned by the NDA and operated under the management of Westinghouse Electric UK Ltd.

In April 2010, Westinghouse entered into an agreement with the NDA for a long-term lease of the site and for the transfer of responsibility for the commercial manufacture of reactor fuel elements and the production of enriched uranium hexafluoride.

The Springfields site is currently licensed to discharge Technetium 99, Thorium 230, Thorium 232, Neptunium 237, Uranium and other transuranic radio nuclides, via 2 pipelines to the Ribble Estuary and hence to the Morecambe Bay.

It seems most unlikely that one, or both, of these fuel factories will not tender for the contract to manufacture fuel for the proposed fleet of at least 16 new reactors. In the event that this happens, it seems highly likely that the contract to manufacture fuel rods for any AP1000 or UK EPR reactors built in the UK will be given to one or other of these factories.

N.B. In the context of the proposed new build of a UK reactor fleet it must be remembered that such a development will inevitably increase the maritime transport of radioactive materials with an increasing inflow of uranium products, enriched or otherwise, being generated by the development.

11. **Summary**

- If approved, there will be 5 new power stations (and up to **15** new reactors) discharging aqueous radioactive wastes in to the Irish Sea.
- Such reactors will also be discharging gaseous and particulate wastes with potential (but un-quantified) wash out and fallout into the marine environment and terrestrial watersheds and rivers discharging to sea.
- Aqueous wastes will consist of up to 65 dissolved and particulate radio-nuclides.
- Tritium is a nuclide of particular concern in light of high proposed discharges and evolving doubts about "earlier orthodoxies".
- Also of particular concern (due to their long half life or radio biological effects) are Carbon 14, Caesium 137, and a number of alpha emitters and actinides including various isotopes of Plutonium and Americium.
- Given discharge quantities are hypothetical only and mostly exclude "contingencies".
- It is proposed that the reactors will have a 60 year operating life span.
- UK wide, there may be up to 24 reactors requiring uranium based fuel.
- One or both of the UK's currently operating nuclear fuel factories will undoubtedly tender for the contract to manufacture the required fuel.
- Both of the UK's currently operating nuclear fuel factories have existing aqueous and atmospheric discharges: additional manufacturing contracts will increase the volume and concentration of these discharges.
- As can be seen from the figures discussed in earlier paragraphs, the potential direct discharges to the marine environment from the proposed new reactors will be many TBq per year (million million Bequerels).
- Many of the nuclides to be discharged have extremely long half lives in their own right, others have decay products with similarly long half lives and thus the potential for long term elevation of concentrations of various isotopes in the marine environment is very high.

11. **Actions**

a) The NFLA is continuing to seek clarity with the Environment Agency over aquatic discharges into the marine environment and remains highly concerned with the permitted levels of discharge and the effects these may have on the environment and on human health, which has been outlined in previous NFLA policy briefings.

b) The NFLA publicises these concerns to allow its members and other groups to know of the uncertainties and to challenge the Environment Agency to seek more information from Areva and Westinghouse on the level and safety of such discharges.

c) In co-operation with KIMO International (the local authority marine pollution organisation), the NFLA will raise these concerns with the UK and Irish Governments and the Radioactive Substances Committee of the International OSPAR Commission.

d) The NFLA will seek to develop a more detailed briefing with other nuclear policy and marine pollution groups allowing for these issues to be developed further, and for discharges into the air to also be considered in more detail.

e) Monitor progress with the HSE / Environment Agency's Generic Design Assessment and submit this briefing for their consideration.

f) Include the findings of this briefing in the NFLA's submission to the UK Government's National Policy Statement (NPS) on Nuclear Power Generation. Chapter 6 of this submission relates to radioactive waste and discharges. The Appraisal of Sustainability and the Habitats Regulations Assessment have important areas for which this briefing is relevant. In addition, the NFLA is discussing with other independent consultants the potential affects of aquatic radiation discharges on protected species around these sites, as the developing science on the effects of radiation on wildlife suggests these concerns also need to be considered.

The UK Government's re-consultation on its National Policy Statements on energy closes on the 24th January 2011. The relevant sections as per this NFLA briefing can be found at: https://www.energynpsconsultation.decc.gov.uk/nuclear/appraisals_of_sustainability_en6

And: https://www.energynpsconsultation.decc.gov.uk/nuclear/habits

The NFLA will seek to provide a briefing for NFLA members by the end of the year and will respond in detail to the UK Government's re-consultation. A briefing and event for UK MPs is also being developed prior to the end of this consultation.

Briefing prepared by: Tim Deere-Jones, November 2010
Actions prepared by: Sean Morris, NFLA Secretary and approved under delegated authority by the NFLA Chair, December 2010.