The Scottish Association of Emergency Planning Officers

Nuclear Study

CSB Faslane

3-4 February 1994

Could We Cope with a Nuclear Accident? A Review of Navy Nuclear Reactor Accident Hazards and Emergency Planning Practice at X Berths

Stewart Kemp
Principal Policy and Research Officer
Nuclear Free Local Authorities

Introduction

This paper sets out nuclear free local authority policy, highlights some potential accident hazards associated with the operation of nuclear propulsion systems, and considers some of the issues to be resolved for an effective emergency planning response.

Matters reviewed include:

* Justification of risk
* Navy nuclear reactor 'design' accidents
* Accident likelihood
* Potential accident consequences
* Basis for emergency planning
* Public information
* Warning and monitoring
* Emergency reference levels
* Potassium iodate tablet (PIT) administration
* Conclusion and Recommendations

Justification of Risk

The International Commission for Radiological Protection's first principle of radiation protection is that any risk arising from the use of radioactive materials must be justified by the benefits it brings.

It is not clear how MoD would provide a justification for risks associated with the operation of navy nuclear propulsion systems or deployment of navy nuclear weapons but the likelihood is that MoD would say justification lies in the electoral process which consistently returns a majority of MPs favouring the deployment of both nuclear propulsion systems and nuclear weapons. This line of argument would be consistent with the view reached by the Health and Safety Executive (The Tolerability of Risk from Nuclear Power Stations 1992) that the tolerability of societal risk arising from the operation of civil nuclear power plants in the UK is ultimately a matter for Parliament to decide.

However, if it is the case that justification is tied to a political process, then whether any nuclear facility, X berth or otherwise, should be tolerated is a legitimate matter within democratic society for debate by the public (including Faslane Peace Campers) and their representatives at local authority level. This view has the endorsement of the Parliamentary Defence Committee which reported in 1992 (HC 337 para.5):

> "...the justification for Trident, the number of warheads to be deployed and the relationship of the scale of the strategic deterrent to that deployed by any potential enemy are once again legitimate political and military issues (for debate)..."

It also has the endorsement of the Defence Secretary who in Parliament, when publishing the MoD Chief Scientific Adviser's report on the safety of UK nuclear weapons, July 1992, acknowledged that it was a matter of legitimate public interest.

It has always been the view of nuclear free local authorities that they are entitled to engage the debate about the justification for nuclear processes and that it is not a matter exclusively for central government.

Whilst working with civil and military nuclear operators to secure the best possible arrangements for the protection of the public, nuclear free local authorities reserve the right on behalf of the communities they represent to campaign for the removal of processes which gives rise to risk. In the context of today's presentation that means retiring and mothballing nuclear propulsion systems and nuclear weapons pending resolution of the dilemma about how to safely manage the legacy of nuclear materials and contaminated waste arisings into the future. Currently in the UK military radioactive wastes account for about 20% of all arisings.

<u>Navy Nuclear Reactor 'Design' Accidents</u>

Navy nuclear propulsion reactor emergency planning derives from a judgement about the probability of different types of accidents happening. These include:

* a release of gaseous fission products from the reactor

* substantial failure of reactor fuel cladding

* core meltdown

Failure of fuel cladding and meltdown are only likely through loss of coolant arising from pump failure or fracture or failure of the cooling circuit. Providing the primary containment does not fail the accident consequences are expected to be limited to gamma radiation penetration of the submarine hull ('gammashine') and through the primary containment boundary some leakage of fission products (e.g. at points of entry for cabling) into the submarine hull - the 'secondary containment'. In such circumstances entry and exit from the submarine by personnel could be expected and this would allow some fission products to escape to the atmosphere.

Teaching notes from the Royal Navy College at Greenwich state:

> "...for planning purposes, it is assumed that 1% of all fission products in the reactor core leak out over 24 hours, and that a further 10% of those are released to the atmosphere."

To try and get some sense of perspective on what a release to atmosphere of this order might mean a crude 'back of the envelope' calculation of what the Navy consider to be 'reasonably foreseeable' can be undertaken (see box).

Reasonably forseeable 'design' accidents are not worst case scenarios. The Navy acknowledge that collision; fittings propelled under pressure within the hull; or leakage from penetration through the bulkhead, could all result in larger releases but no known reference exists in the open literature about the amount of radioactivity that might escape. However, if a modest 1% release to atmosphere is assumed, then working to the calculation below (box) it could equate with 1/25 Chernobyl or 2/25 THORP.

In any navy propulsion system release the dominant radionuclides would be Iodine 131 (½ life 8 days) and Caesium

137 (½ life 30 years). Countermeasures for radioactive iodine are discussed below. Caesium is a more difficult problem and has shown itself to be very persistent in peaty soils and the plant and animal life that live upon it. Eight years after Chernobyl agricultural restrictions - though steadily reducing - are still in place in some upland areas of the UK.

'Design' Release Calculation[1]

Core activity = about 10 Ci[2] per watt output
Assumed Propulsion PWR power = 20Mw?[3]
Assumed total core activity = about 200m Ci
Atmospheric release = about 0.1%
Therefore activity released = about 200,000 Ci
Chernobyl estimated release = about 50m Ci[4]
THORP annual discharge authorisations (air and sea) = about 25m Ci
Therefore 'planning accident' = about 1/250 Chernobyl atmospheric release or about 1/125 THORP authorised discharges to air and sea.

<u>Notes</u>

1. Different radioactive isotopes with different rates of decay and consequences are involved in the different examples.
2. 1 Ci.= 3.7×10^{10}bq
3. This is probably a low estimate. Other estimates place power rating as high as 100Mw (1/10 commercial PWR output). The precise figures for any of the Navy's propulsion systems are not disclosed in the open literature because, it is argued, operational characteristics of the vessels concerned could be inferred.
4. This too is probably a low estimate. Some recent research places the atmospheric release up to x5 higher.

How Likely is a Reactor Accident?

While submarines are berthed and the reactor is shutdown or operating at low pressure the risk is low. However, 'Greenwich' teaching notes also point out:

> "The possibility, though very remote, of a nuclear accident occurring *is greatest* at X berths since at these berths initial criticality and power range testing of nuclear plant are carried out as well as fast cruise operation for crew training"(emphasis added).

The Navy calculates that the likelihood of its 'design' ('reasonably foreseeable') accident to be about 1/10,000 years. A catastrophic failure is calculated as having a likelihood no greater than 1/1,000,000 but the reality is that these theoretical probabilities are not very helpful for emergency planning purposes. At Faslane, the potential hazards of nuclear weapons and missile propellant in close proximity to a reactor on Polaris and their successor Trident boats must also be 'factored in' adding to the difficulties of probabilistic risk assessment.

Nuclear free local authorities would argue that historical operational experience is a better guide, and while there are no known Royal Navy leakages of radioactivity to atmosphere, international operational experience is not so good.

In the Bulletin of the Atomic Scientists July/August 1989 Arkin and Handler detail 8 nuclear reactors lost at sea including atleast one meltdown. These reactors if not already doing so, will over time release their radioactive inventories to the marine environment. These are 'worst case' 1/1,000,000 accidents which, with about 400 navy propulsion systems operational worldwide, should occur with a frequency of about 1/2,500 years. The reality in about 30 years of operation is one loss every 4 years. These did not happen during port visits but they do serve to illustrate the gulf between theory and practice.

At the June 1992 nuclear free local authorities conference in Glasgow about Trident, Greenpeace revealed for the first time, from records of the former Soviet Union, that in the five years to 1992, no less than 46 accidents had occurred on their nuclear propelled or armed vessels. Greenpeace had previously only recorded 12 accidents for the same period. The operational record for the Royal Navy cannot be independently verified although information published in the Journal of Navy Science (Vol.5 No.2 1978) reports 712 'incidents' between 1964 and 1978. Earlier, JNS (Vol.4 No.4) reported:

> "...'incidents'...are defined as events requiring operation away from the norm and which include all occasions when emergency drills have been initiated. In all these 'incidents' the remedial actions taken have been successful; no British nuclear submarine has been lost, although a major fire has required the lengthy withdrawl from service of one boat, and it must be emphasised that no incident has occurred which has caused a radiological hazard to the public."

More recently the press reported a fire on HMS Valiant while berthed at Faslane on 5 August 1989, although the Navy insist this was not a serious incident, and before retirement, fires were reported on HMS Conquorer at Devonport in 1987 and Gibraltar in 1988.

Planning Zones and Accident Consequences

Based on what is considered 'reasonably forseeable', because to do more is not thought worthwhile, X Berth emergency planning zones are determined as follows:

* 50m radius evacuation zone for unprotected personnel to avoid exposure to gamma radiation penetrating the submarine hull;
* 550m radius designated for automatic contermeasures e.g. sheltering, evacuation of non essential personnel and potassium iodate tablet (PIT) administration;and
* 10km radius from an accident source, designated for the purpose of food and milk consumption restrictions if levels of radiation or radioactive particle deposition, either monitored or predicted, is assessed to require it.

In contrast, ex AEA Engineer, John Large, investigated the then Soviet planning practice at their Murmansk base on the Kola peninsula. In September 1991, in a report commissioned by Greenpeace, Large wrote:

"The Murmansk (naval base) Emergency Plan provides a number of reactor and associated plant and fuel storage accident scenarios and, importantly, includes nomination of a very serious reactivity excursion accident that would not be considered credible in the West. This reactivity excursion accident results in very serious health consequences within the concentrated population of the city of Murmansk, together with additional health consequences extending as far as 1000km from the accident site.

The average anticipated dose for individuals within the 65,000 Murmansk group is reckoned to be as high as 1Sv. (NB. More than x3 the level at which the NRPB advise evacuation and PIT administration). This is the level at which irreversible physical changes (long term health damage) are acknowledged to commence.

Symptoms could include: onset of nausea, coughing and vomiting, blood cell changes, flushing of the skin. Of the higher-band exposure group (26,000), it can be expected that at least 30% will die in the short or medium term...

...Although there are deficiencies in the Murmansk plan, particularly in equipment resource and organisation, the plan boldly recognises the possibility of a severe accident and the ensuing massive consequences."

According to Large, the propulsion reactor in the service of the then Soviet fleet is similar in scale and design to that in the service of the Royal Navy.

Clearly, any accident consequences would depend on several factors including the type and quantity of material released; length of time of release and weather conditions; demographic factors and the speed of effective countermeasure implementation (including at X Berths continuous spraying of a stricken submarine to cool the hull and wash out some escaping radioactivity). However, the data from the former Soviet Union indicates the degree of underpreparedness in the UK.

Planning for Possible Accidents

After Three Mile Island, a Federal Government Joint Task Force, established to investigate the accident, concluded that planning should be "... capable of accomodating a possible accident involving a core meltdown and breach of containment"(emphasis added).

The Inspector to the Hinkley Point Planning Inquiry for a commercial PWR recommended planning guidance for a wider area be issued to the emergency services and local authorities for a 'beyond design base' accident. Outline planning to 40km was recommended. The Nuclear Installations Inspectorate of the Health and Safety Executive published guidance for planning a response to a beyond design base accident in 1990 and some additional emergency planning has been undertaken though not to the distances recommended by the Hinkley Inquiry inspector.

The Navy should consider how its arrangements could be extended beyond the 10km zone, particularly in view of its own assessment, set out in 'Greenwich' course notes, that 'Emergency Action Guidance Levels' for PIT administration i.e. a 50mSv predicted thyroid dose, could be exceeded in a worst case accident out to 100km.

Infact, in relation to civil emergency planning, Government has partially conceded the case, by amendment to Section 138 of the Local Government Act 1972 through the Local Government and Housing Act 1989, that local authorities can plan for 'possible' rather than more narrowly defined 'reasonably foreseeable' major hazards.

For X berths, where local agreement has been reached to extend the area for countermeasure implementation, the MoD have stepped in to prevent it. At Rosyth the public safety plan revised and issued in September 1992 extended the countermeasure zone from 550m to 2km. The plan had the support of all the relevent authorities, including the Navy at Rosyth, but MoD in London wrote on 16 September 1993 to Lothian Regional Council stating there is:

> "...no requirement for either the urgent evacuation of people or the issue of potassium iodate tablets beyond 550 metres. Detailed emergency planning therefore takes place within this 550m zone. All Public Safety Schemes are deliberately made flexible; for example we have outline plans to distribute potassium tablets out to 2km..."

How flexible plans would be extended is a matter which has never been explained, or to the author's knowledge demonstrated, in either civil or military nuclear emergency planning.

Public Information

The Chernobyl disaster gave rise to EURATOM Directive 89/618 which required Governments of EC Member States to provide advance information to the public where they are covered by an emergency plan. The Directive also required information be given to all those affected or at risk from an actual radiological emergency. The European Commission described the Directive as "...a new principle in practical radiation protection for the public..." but this is not the spirit in which it has been received in the UK.

Advance information as follows should be provided to all those covered by an emergency plan:

* basic facts about how radioactivity affects people **and the environment**
* types of emergencies and possible consequences
* alert procedures
* action to be taken in the event of an emergency

However, the Health and Safety Executive, drafters of the Public Information for Radiation Emergencies Regulations 1992, which enacts the Directive in the UK, have tied the duty to provide advance information to only those areas which could be affected by a 'reasonably foreseeable' radiation emergency. This has had the effect of limiting prior information distribution at civil nuclear sites to those households which already receive advance information under existing emergency planning, and although introducing advance information at some military nuclear sites, in the case of X Berths, limits information distribution to 2km radius of the accident hazard i.e. reactor propulsion system. This is an inadequate area for emergencies 'beyond the design base'.

Nuclear hazards engender fear in people. Accident effects and countermeasures are not well understood and Government has shied from the opportunity to tell people. In so doing it actively contributes to public ignorance.

Warning

For both civil and military authorities - and the public to be able to react appropriately to help themselves in an emergency - a prompt alert mechanism is required. Public attention must be captured so advice can be given about how radiation dose uptake can be avoided.

The Hinkley Inspector described the arrangements for warning the public in the event of a nuclear emergency as a problem "crying out" for resolution. After the Hinkley Inquiry the Home Office established a working party to review arrangements for public warning but this did not result in any new initiatives. There is no national warning system for any major emergencies.

Arrangements for public warning at X berths are not familiar to the author but automated sirens (if they exist) will not cover an area much beyond a base perimeter fence and it has been argued above that populations over a much wider area could be affected and may need to shelter (possibly as a precaution) or take PITs. A radioactive plume on a 15km/h breeze would travel 45km in 3 hours. It is clear that speed is essential for effective countermeasure implementation.

Monitoring

Prompt warning to shelter a population which could be affected by a radiation emergency is required until initial projections and modelling of radiation and radioactive emissions to atmosphere can be translated into facts from collated monitoring data. Notes from Royal Navy College, Greenwich, dating from the late '70s state:

> "There is no way of predicting the magnitude of release and it may well be up to 12 hours before a true picture can be obtained so all the immediate actions are preplanned."

These same teaching notes explain the different stages of monitoring leading to an assessment of ground contamination for the purpose of deciding whether food or drink restrictions are required. This, according to the Navy, may take several days to complete.

More recently, it is reported that the 1993 'Short Sermon' public safety plan emergency exercise at Devonport took 24 hours to collate all notional radiation monitoring information.

Action Levels

Action in an emergency is based on projections of potential doses and dose avoidance through the implementation of countermeasures. The National Radiological Protection Board who advise Government, argue that implementation of countermeasures should be "justified", that is to say that they "...should be introduced if they are expected to achieve more good than harm" (Documents of the NRPB Vol.1 No.4 1990). Factors influencing countermeasures decision making include health, economic and social effects.

The NRPB advise that below 3mSv anticipated whole body radiation accumulated dose to the public within the following 12 months, countermeasure implementation is likely to do more harm than good. (3mSv is six times the annual average maximum exposure dose limit from all manmade sources recommended by the NRPB in normal circumstances). Between 3-30mSv sheltering should be considered, between 30-300mSv sheltering should be implemented while evacuation and potasium iodate distribution is considered, and above 300mSv evacuation and stable iodine tablet distribution should be implemented. These recommended dose limits are called Emergency Reference Levels (ERLs).

At the Eighth International Conference on Radiation and Health in Newcastle, July 1992, nuclear free local authorities expressed concern about the difficulties in 'factoring in' all the variables during a developing emergency to decide the point at which to act. Indeed, NRPB have strongly recommended "precautionary countermeasures" stating:

> "Although the Board has specified ERLs of averted dose for the introduction of countermeasures, these are not intended to imply that no countermeasures decisions should be taken until detailed estimates of the likely averted dose can be made."

It is now understood that NRPB may be in the process of firming up advice on specific action levels for countermeasures in nuclear emergencies at civil sites which would bring practice in line with that already established at X berths through the mechanism of 'Emergency Action Guidance Levels'.

Potassium Iodate Tablets (PITs)

Plans to distribute stable iodine tablets in an emergency continue to develop. Nuclear free local authorities have consistently argued for wider tablet **predistribution** to ease the task in an emergency. The Department for Health in new guidance issued late last year stated distribution arrangements were a matter for local agreement but wrote in 1992 to the nuclear free local authorities' Secretariat in the following terms:

> "...existing guidance to Health Authorities states that Health Service arrangements *must involve actively all HAs within at least 40km radius of a nuclear installation*. Centrally held stocks are currently held at various locations. More specific guidance on these matters will be considered once discussions on extendibility have been concluded"(emphasis added).

Currently Health Emergency Planning Officers are developing plans to distribute PITs from preestablished stockholders to a population which could be affected. The need for prompt advice and prompt PIT dose administration does not lend itself to easy solutions even given the limited 2km radius outline planning around X Berths, and ignoring the recognition by the Navy itself that in some circumstances PIT administration could be required out to 100km.

It is reported that a current draft plan for PIT administration for the Devonport X Berth envisages collection from distribution points but this would involve the public breaking shelter and as a result potentially increasing exposure. It is perhaps a mark of the difficulties associated with this aspect of emergency planning that several decades on there is no concensus about policy towards planning. It is not known whether any progress has been made on plan 'extendability' for emergencies which may affect populations beyond 2km. Outline planning for 100km will not have been considered.

Conclusion

This paper has not covered all aspects of planning for a radiation emergency e.g. effective sheltering and arrangements for evacuation, introduction of food and drink restrictions, or decontamination and clean up. But on the basis of those aspects of planning which have been considered i.e. warning, monitoring and PIT administration, it is difficult to conclude that a response for emergencies beyond the 'design' accident can be effectively mounted because planning difficulties for a 'design' accident have not been fully resolved and 'extendability' is a term often invoked, but little explained when considering 'beyond design base' accident hazards.

Recommendations

It would help to understand the basis of planning for public safety at X Berths if the Navy would:

1. Explain the sequence of events which lead to both 'design' accidents and those which could require countermeasure implementation at 100km.
2. Explain the core inventory of reactor propulsion systems and show how for different accident scenarios radioactivity released to atmosphere is modelled.
3. Extend the distribution of public information so the public are better informed in advance about what might need to be done in a radiation emergency. Subject to the determination of natural boundaries, the current 10km 'outline planning' area would seem a reasonable and practical range for coverage.
4. Explain the mechanism for the flexible extension of each countermeasure should a 'beyond design base' accident happen.

3 February 1993