Review of the Emergency Planning Measures Relating to the Berthing and Maintenance of Royal Navy Nuclear Powered Submarines at Faslane, Coulport, Lochgoil, Rothesay and Loch Striven

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NUCLEAR SAFETY AT Z AND X BERTHS LOCATED IN SCOTLAND
OFF-SITE CONTINGENCY PLAN HM NAVAL BASE CLYDE – FEBRUARY 2001 DRAFT ISSUE

ABSTRACT

This review assesses the hazards associated with nuclear powered and armed submarines operating about the Clyde submarine berths and the nuclear weapons arming facility at Coulport.

The hazards include accidental detonation of a conventional explosive munitions carried on board, such as a torpedo round, which is of sufficient magnitude to damage the nuclear reactor plant and result in a release of radioactivity; fire and fragmentation of a nuclear warhead and the atmospheric release of plutonium radioactivity from the warhead itself; and serious malfunction of the nuclear reactor plant and release of radioactivity beyond the containment of the submarine hull.

The Review shows that for each of these accidents airborne radioactivity could spread from the accident site to necessitate evacuation and sheltering of members of the public. For a submarine reactor plant accident, distances extend to 10 km for evacuation, 20 km for sheltering, and up to and beyond 30 km for issuing of stable iodine tablets. For a nuclear weapons accident, public evacuation and/or respiratory protective measures might be required for 10 to 20 km and sheltering for up to 40 km from the accident centre.

The draft of the Argyll and Bute Off-Site Emergency Plan (Clyde Plan) is evaluated in terms of its effectiveness to counter these accidents and mitigate the consequences to health of members of the public due to radiation exposure.

First, it is shown that the Clyde Plan would need to put in place robust countermeasures well beyond the present 2 km pre-planned countermeasures zone. Second, although the Clyde Plan claims to cater for a nuclear weapons accident, there are no specific measures and resources in place that could usefully be applied to mitigate the consequences and, indeed, the Plan suggests that stable iodine tablets would be issued which would be a totally inappropriate and confusing action.

Second, the measures identified in the Clyde Plan suggest that a submarine reactor accident would be a relatively leisurely event, taking some hours to develop, leak and disperse radioactivity into the environment. In fact, the *Category 3* accident identified by the Ministry of Defence, but not cited within the Clyde Plan, indicates that a very large release of radioactivity could occur within 10 to 20 minutes of the initiating event. The Clyde Plan could not provide such a rapid response and for a *Category 3* accident there is risk of unacceptably high radiation exposure to members of the public.

The Clyde Plan is reviewed in terms of the *Radiation Emergency Preparedness and Public Information Regulations* (enactment expected June/July 2001) and found to fall short of these by a number of important criteria, particularly, in that the Ministry of Defence has failed in its obligation to inform the local authority of all of the hazards (severity of damage and release of radioactivity) and the risks involved (probability and speed of development of the release).

In effect, the failure of the Argyll and Bute local authority to provide and adequate off-site emergency plan, as will be required by the new regulations, means that the nearby local communities will be subject to unnecessary risk should an accident and radioactive release occur.

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4 May 2001

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INTRODUCTION

The draft contingency plan for HM Clyde (the Clyde Plan) claims to satisfy the requirements of the *Radiation Emergency Preparedness and Public Information Regulations* (REPPIR)[1] that, in effect, will supersede the obligations of the Ministry of Defence (MoD) under *Regulation 26* and *27* of the *Ionising Radiations Regulations*.

The Clyde Plan applies to serious nuclear accidents arising in the nuclear powered propulsion plant of Royal Navy submarines alongside the designated 'Z' and 'X' berths, for submarines on passage (under way in the approaches, etc) to these berths, and for incidents involving nuclear weapons at the Coulport Depot.

IDENTIFYING THE HAZARDS AND RISKS

All classes of nuclear powered submarine are armed with conventional weapons comprising high explosive warheads and propellants.[2] In addition to conventional weapons, the Vanguard class of ballistic missile launching boats (SSBN) carry ballistic missiles and nuclear warheads.[3] A nuclear propulsion plant, comprising a nuclear reactor and primary circuit, steam raising generators and steam turbines, powers all Royal Navy submarines.

1) Conventional Weapons – Torpedoes, etc

The hazards present from an inadvertent explosion of a conventional weapon have been demonstrated by recent losses in the Russian Federation submarine flotilla with a single round explosion being sufficient to initiate reactor plant damage.[4]

2) Trident Missiles and Nuclear Warheads

The hazards arising from the Trident missiles are associated with both the missile propellant and the nuclear warheads. A missile malfunction and ignition of the propellant whilst in its silo could imperil the warheads and trigger detonation of the conventional high explosive charges that surround the fissile pits of the individual nuclear warheads. This accident, even if it did not result in damage to the nuclear reactor plant of the submarine, could result in aerial release and dispersion of radioactive particulate plutonium and other materials and substances of a nuclear warhead assembly.[5]

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1 These regulations supersede the requirements of the Ionising Radiations Regulations that place a duty on the nuclear operator to assess the nature and extent of the hazard and the radiation exposure and health and safety relating thereto. Draft Regulation 18 provides opportunity for exemption although it is believed that the Secretary of State for Defence will not seek this.

2 Both SSN (attack) and SSBN (missile) submarines carry a complement of torpedoes and surface skimming missiles (Harpoons) and the Trafalgar Class SSN are being fitted with cruise missiles (Tomahawks). The SSBN carries 16 Trident ballistic missiles, each capable of carrying 6 independently targeting nuclear warheads.

3 The SSBN is also armed with 16 Trident ballistic missiles, each capable of carrying 6 independently targeting nuclear warheads, although a complete consignment of missiles and warheads may not be deployed on board at any one time.

4 Although yet to be confirmed, it is almost certain that the Russian Federation SSGN *Kursk* was lost as a result of a torpedo round explosion following fire and explosion of the torpedo propellant and, earlier in 1989, the SSN *Komsomolets* was a total loss when a torpedo round exploded in the bow compartment storage racks - *Dispersal of Radioactive Materials from the Komsomolets Submarine*, Large & Associates, August 1993

5 Typically, a nuclear warhead includes 30 to 50 kg of conventional high explosive which is sufficient in accidental detonation conditions to oxidise and disperse the 3 to 5 kg of plutonium (Pu^{239}) and other radio and chemo-toxic materials of the warhead assembly, including tritium, depleted uranium and beryllium - *The Hazards of Transporting Nuclear Weapons Through Urban Areas*, Large & Associates, National Steering Committee of Nuclear Free Zone Local Authorities, January, 1990

In an accident situation, say, involving a fierce fire of the missile propellant in the submarines launch silo or on the ground because of a mishap during loading, there is risk that the conventional explosive charges making up each of the nuclear warheads may ignite, burn and, in some cases, detonate.[6] The plutonium fissile core of each warhead is a chemically reactive metal which is pyrophoric at relatively low temperatures (220°C), so a burning weapon core would readily disperse to the atmospheric environment in the form of finely divided oxides, the greater part of which would be of respirable size.

The failure of one to all six of the nuclear warheads carried by the missile, each liberating between 3 to 5kg of α-emitting plutonium, could result in the following radioactive release:[7]

SCENARIO	RELEASE MODE	AMOUNT TBq	TIME SPAN
Single or all warhead HE Charge ignition and burning of Pu core to particulate oxide form	Radiation shine negligible, respirable sized particles released to atmosphere	11 to 60 half-life 23,390 yr	< 1 hour

3) Submarine Nuclear Reactor Plant

The MoD[8] identifies three categories of accident severity arising from malfunction of the reactor plant and its nuclear fuel. Essentially, each category relates to the failure of one of four boundaries with *Category 1* being an event leading to, or which has resulted in, the release of radioactive fission products from the fuel plates; *Category 2 is* where the fission products have escaped from the reactor primary circuit but remained contained within the reactor compartment; and *Category 3* is where there is a release of fission products from the reactor hull to the outside environment.

The amount of radioactivity within the fuel that is available for release is determined by the in-core service age of the fuel, which can be up to 10 years, and its recent power operation history. The MoD assumes a *Standard Core History'*[9] with a fission product inventory of approximately:

NUCLIDE GROUP	HALF-LIFE	TBq[10]
Halogens Iodine-131	8.05 days	40,000
Other Fission Products	long-lived	3,960,000
	Core Inventory	**4,000,000**

The radiological consequences for the three accident categories derive from the following release of fission products from the fuel core of the reactor:[8]

6 *Guidance and Information on Nuclear Weapons, Accident Hazards, Precautions and Emergency Procedures*, WASH 1274, US Department of Defence and Atomic Energy Commission, October 1973

7 Partial nuclear detonation of a warhead arising from the accident circumstances is considered just feasible, although not considered here.

8 MAPC Hazards of a Reactors Accident, Royal Naval College, Department of Nuclear Science and Technology (S)CM/13/88/WM, October 1992

9 The MoD Standard Core History assumes the reactor core to be at the end of its service life, that is highly irradiated, and that it has operated at full power for the immediately previous 100 hours and at 25% power for the remainder of its life.

10 1 TBq = 10^{12} Becquerel

MoD Category - Scenario	Release Mode	Amount TBq	Time Span
1) Fuel Clad Failure	Local γ shine only	~	~
2) Loss of Coolant, Core Melt & Fission Products into Reactor Compartment	γ shine up to 400 m	400 to 4,000 (4 – 40 I^{131})	24 hour seepage, mainly of iodine and other fission gases
3) Loss of Coolant, Core Melt, Hydrogen Burn & Loss of Hull Containment[11]	γ shine > 550, large high energy fission product release	40,000 to 4,000,000 (400 – 40,000 I^{131})	10 to 20 minutes blow out following initial triggering malfunction

IMPLEMENTATION OF MITIGATION AND COUNTERMEASURES

In radiation emergencies mitigation and countermeasures are implemented in order to avert levels of radiation dose exposure to individuals and critical groups of individuals. These levels are prescribed by the NRPB[12] and are referred to as *Emergency Reference Levels* (ERLs), being applied to the total exposure or *whole body dose*, and the *single organ dose*, which is particularly applied to the thyroid uptake of radioactive iodine (I^{131}).

The lower ERL is defined to be the level of dose below which no benefit would arise if countermeasures were implemented. The upper ERL is the level of dose that should be averted and not exceeded by the implementation of appropriate countermeasures. Both ERLs by far exceed the natural background radiation levels and individuals subject to these levels of radiation exposure would in a relatively short time be exposed much above that permitted annually (1 mSv/year).

i) **Application to a Submarine Accident**

Evacuation: The prescribed ERLs for evacuation of members of the public are set at 30mSv lower and 300mSv higher. Applying these ERLs to the three categories of damage severity identified for the submarine nuclear reactor power plant, requires population evacuation downwind of the *Category 3* accident out to 9.5 km[13] - see **GRAPH 1** (attached).

Importantly, the development of the *Category 3* reactor compartment blow out scenario, in its extreme, takes place over the very short time period of 10 to 20 minutes from the occurrence of the initiating loss of coolant in the reactor plant. So, depending on wind speed and development of the radioactive fall-out plume, advising and organising members of the public nearby the accident centre, say out to 5 km, would have to be implemented quickly, say within 30 minutes to 1 hour, if the consequences are to be minimised.

Sheltering: Further downwind of the accident centre the public would be required to shelter up to a distance 20 km for the *Category 3* accident scenario and out to 2 km for the *Category 2* accident – **GRAPH 2.**

Organ Dose: The ERL thresholds for individual organ doses are applied separately from the whole body dose. This is because the accident circumstances might require specific prophylactic measures to be implemented to protect members of critical groups before those

11 This scenario comprises a loss of primary coolant via failure of an unisolable section of the primary circuit, rapid boiling of the water remaining around the fuel core and a fuel clad (zirconium alloy) steam reaction which exothermally liberates hydrogen with the sequence moving on to a hydrogen burn at about 10 to 20 minutes and which is sufficiently energetic to rupture the hull section of the reactor compartment. In another sequence the fuel core melts at about 1,700°C at 2 to 3 minutes into the scenario, the molten fuel drops into a pool of water remaining in the bottom of the reactor pressure vessel causing a violent molten metal-steam explosion which generates a very high pressure pulse sufficient to rupture the hull.

12 National Radiological Protection Board, which acts as the advisor to Government.

13 All the graphs are plotted for average weather conditions and take little account of the local terrain or urban centres within the path of the plume – terrain, weather and, particularly, plume wash out from precipitation can introduce variations of x5 to x10 and the plume development, its direction and coverage area will depend on the wind direction and strength. The whole body and organ doses are expressed in terms of the 50 year committed dose.

individuals reach the whole body dose ERL.

For a reactor plant that has a recent history of power operation, any radioactive release will include the gaseous fission product iodine (I^{131}) that, via inhalation, will be reconcentrated in the thyroid gland. The prophylactic measure is to swamp the thyroid gland with iodine introduced by potassium iodate tablets (PITs) taken orally in advance of the arrival of the plume carrying the radioactive iodine.

For the *Category 2* accident PITs would have to be issued out to 1.1 km and for *Category 3* PITs would have to be issued out to 30 km downwind from the accident scene – **GRAPH 3**.

MAP 1 shows the application of the Whole Body Dose evacuation and sheltering ERLs for *Category 2* and *Category 3* at the Faslane berths. The same radial distances for public evacuation, sheltering and prophylactic measures would apply to radioactive releases occurring at the other submarine berths.

ii) Application to a Nuclear Warhead Accident

As previously explained, two mechanisms exist within the warhead to provide for this dispersion, these mechanisms are detonation of the warhead high explosive charge and or burning of the charge and plutonium. These events might be preceded by burning of the missile propellant in the launch silo or some other disruptive event at the explosives handling jetty when the Trident missiles are being loaded with the complement of nuclear warheads.

Subject to detonation or fire, the plutonium pit of the warhead will aerosolise into small particles[14] that are readily borne aloft and dispersed in the atmosphere. In the immediate aftermath of the accident, where the high explosive has detonated or burnt, the plutonium particles are available for direct inhalation by individuals downwind. In the short, medium and longer terms, plutonium particles deposited on the ground, on building and other surfaces could enter the human metabolism by ingestion, open wounds and other routes or, if resuspended by disturbance, inhaled.

The scale of consequence in the aftermath of a nuclear weapon accident obviously relates to the severity of the accident. The United States authorities openly acknowledge that there is risk, albeit remote, that a warhead could undergo partial nuclear detonation in an accident and, if so, this accident would be accompanied by the release of fission products and nuclear blast, both related to the partial nuclear yield.

In scale of severity the next conceivable accident could involve conventional detonation of the HE charges of one or more warheads, dispersing the plutonium aerosol over a wide area, estimated by the US authorities to extend 40km or more from the accident site. Ignition and burning of the HE charge (and plutonium) would also serve to disperse the plutonium over a wide area, estimated by the US to involve 5 to 10 km of land beyond the immediate accident site.

The United States adopts a Radiation Protection Guide (RPG) that sets the maximum concentrations in air and water following a nuclear weapons accident for the various component parts of a nuclear warhead, with the Pu^{239} airborne maximum at 6.10^{-14} micro-curies per millilitre.[15] Because of the rapidity of events and the likely high energy of

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14 Particles of plutonium oxide down to below 10 to 1 micron, or smaller, in equivalent diameter are formed during the ignition and these may disperse freely of combine with or attach to other particles of debris or emulsions of the propellant etc., to be carried away from the site of the accident.

15 RCG gives the levels above background for outside restricted areas following a nuclear weapons accident, for the soluble compound forms and radionuclides of americium, beryllium, tritium, plutonium, thorium, uranium. Another limit adopted is the US Code of Federal Regulations

dispersion and, particularly, the difficulties of measuring airborne concentrations of plutonium, initiating sheltering, evacuation and inhalation protection countermeasures at the onset of ERLs is not adopted in the response to a nuclear weapons accident.

Instead, the primary task of the emergency services in dealing with a nuclear weapons accident is that of evacuating people out of zones where the inhalation hazard prevails.[16] The United States adopts an immediate evacuation zone of 2km, a 10km zone in which respirator protection is required and where sheltering is recommended and evacuation should be considered, and a zone extending to 40km where the expectation is that the general public exposure will exceed the annual whole body dose and where sheltering is recommended – **MAP 2** relates these zones to a nuclear weapons incident at Coulport.

In Summary: Nuclear powered submarines are armed with powerful conventional high explosives weaponry and the accidental detonation of a single round would be sufficient to severely damage the submarine and put the nuclear reactor plant at risk.

The Vanguard class of submarines is also armed with nuclear weapons. The accidental burning or explosive break-up of a single nuclear weapon could result in a release of plutonium (and other radioactive substances) requiring an emergency response in attempt to mitigate the health consequences to the population over a relatively large area up to, if not in excess of 40km from the scene of the accident.

The MoD acknowledges and plans for three levels of damage severity arising from malfunctioning of the nuclear propulsion plant. When at sea and in the approaches to port, and when at berth unless the submarine is undergoing a refit or major repairs, the nuclear reactor plant is maintained at operational pressures and temperatures at *Reactor State A*. When at berth, although the power output from the reactor may be low, the physical environment of the reactor plant is the same as that of a fully operational submarine at sea so, it follows, the risk and severity of accident are the generally same as that when the submarine is at sea.

For the worst case *Category 3* accident evacuation of the general public could be required out to 10 km from the scene of the accident, sheltering may be required beyond the evacuation zone out to 20 km, and to suppress radioactive iodine take up prophylactic stable iodate tablets might have to be introduced out to 30km from the accident centre.

However, and seemingly in denial of its own *Category 3* accident scenario, the MoD imply that all reasonably foreseeable reactor accidents are relatively leisurely events that cascade in some predefined orderly manner, each stage of which will serve to implement a further set of countermeasures and actions.[17] Although the MoD undertakes to implement the *'local'* plan in full following the declaration of a reactor accident, irrespective of Category, there is little acknowledgement that certain *Category 3* incidents, particularly stemming from a reactor pressure vessel abrupt loss of primary circuit coolant with fuel melt, would not effectively cascade through the categories or, if such did, the whole cascade would be compressed into a very short time frame of a few minutes.[18]

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that gives a maximum concentration 10-12/m3 in air for plutonium for unrestricted use and there are also limits based on length of exposure, 1 hour, 3 hours, etc..

16 Nuclear Weapons Accident Response Procedures (NARP), US Defence Nuclear Agency, January 1984

17 For example see p26-28 of Section 2, Part A DevPubSafe (the public safety scheme for Devonport) assumes the cascading of the incident through severity Categories 1, 2 and 3.

18 For example, the 1957 Windscale accident took several hours to develop but those operating the atomic pile did not realise what was happening, so although the 'category' of events were cascading in seriousness, the operators did not realise that counter actions were necessary. At Three Mile Island in 1978 the operators misunderstood what was happening and implemented the wrong counter actions. At Chernobyl in 1986, the cause of the accident was rooted in actions taken 24 or more hours before the explosion, only when the train of events

Off Site Plan for the Clyde Berths and Coulport

The new Clyde Off-Site Contingency Plan[19] (the Clyde Plan) sets down background information and guidance on the roles and responsibilities of the various parties involved, including the MoD and the (civil) local authorities, in the event of a nuclear submarine accident.

Applicability of the Clyde Plan

In a general sense, the Clyde Plan provides a reactive rather than proactive approach to contingency planning. This is because, first, it does not identify the type and severity of the incidents and accidents that might evolve to a radioactive release and, second, it does not determine the amount and quality of the radioactive release emanating from all reasonably foreseeable accidents.

Submarine Based Accidents

Although the MoD itself nominates three categories of accidents applicable to a nuclear submarine, none of these are specifically related to the 550 m evacuation zone and the 2 km preplanned countermeasures zone cited in the Clyde Plan. Unlike the present Clyde Public Safety Scheme, which is to be superseded by the Clyde Plan, there is no prepared opportunity to extend the countermeasure zone outwards if and as the radioactive dispersion develops.

For example, damage severity at or above the *Category 2* (through to the worst case *Category 3*) accident would require evacuation, sheltering and issue of PITs beyond 2 km. For those accidents at or nearing the damage severity of *Category 3* the radioactive release would be rapid (in 10 to 20 minutes of the initiating event) and the radiological impact could occur quickly, certainly before the *"some hours before monitoring teams can gather sufficient information to make possible a realistic appreciation of the course of an accident"* referred to in the Clyde Plan (*Section ?.2.4*).

Nuclear Weapons Accident

For the radioactive release deriving from a nuclear weapons accident, where plutonium particles are released to the atmosphere, the profusion of radiological limits, and the variation in these, would render the task of the emergency services of ensuring people are evacuated from unsafe areas or that the immediate decontamination is done to acceptably safe levels. The response to a nuclear weapons accident could not be ERL initiated and the automatic action of issuing stable iodine tablets would be entirely inappropriate.[20]

In fact, other than claiming that the Clyde Plan also deals with nuclear weapons accidents (*Introduction, Para 5*), there is nothing in the Clyde Plan that relates specifically to the processes and procedures required to protect members of the public in the event of a nuclear weapons accident.

ERL Approach and Dependence upon the MoD

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approached terminated did the operators realise that something was desperately amiss, but by then little less than one minute remained before the reactor was completely destroyed.

19 Issue 1, Amdt 0, July 1999 but excludes PART B.

20 Unless the warhead underwent a partial detonation or 'fizzle', no iodine-131 would be present and hence no need for PITs consumption.

In setting out the approach to protection of the public within the pre-planned zone, the Clyde Plan sets out the ERL triggering countermeasures actions (setting aside these are inappropriate for a nuclear weapons accident).

The Clyde Plan seems to be totally dependent upon MoD personnel (Royal Navy) carrying out an assessment of the severity of the accident, undertaking monitoring and, from these, determining (projecting) the radiological impact of the accident. For this the Clyde Plan (*Section ?.2.5*) states that it "*is imperative that there is some form of predetermined plan to protect those who may be at risk in the period before definitive monitoring information becomes available*", but it gives no clue to just what this is in detail and how the local authority is to initiate and implement the appropriate level of countermeasures.

This means that for the pre-planned countermeasure zone (2 km) the Clyde Plan does not relate to the actual radiation exposure dose of individual members of the public (actual or projected) at the time that the countermeasure is initiated, but somehow extrapolates this from the accident *Category* assessment of the condition of the reactor fuel. Since the definition of accident *Category* is vague and, moreover, it unlikely that the Royal Navy would wish to share sensitive information about the condition of a submarine propulsion reactor with a local authority, members of the public in the 2 km zone are entirely dependent upon the uncorroborated assessment of the condition of the rector fuel by naval personnel for their well-being.

Nothing at all is set out in the Clyde Plan relating to the means and criteria by which this assessment is undertaken, how much cognisance is given to critical groups within the public population, its hierarchy of reporting within the MoD organisation at HM Naval Base Clyde and beyond, and its eventual communication to the local authorities. In terms of management processes and the detail of how the countermeasures are to be implemented and administered, the Clyde Plan is particularly lacking.

The Clyde Plan (*Section 2 Annex*) states that the MoD Naval Emergency Monitoring Team (NEMT) will undertake the radiation monitoring but it is not clear whether NEMT is sufficiently resourced to extend its monitoring capability into the public sector. Obviously, in the short time scales afforded by both the submarine *Category 3* accident and the nuclear weapon dispersion scenario, additional or *'back up'* from nuclear power stations in the region will not be available. NEMT's orders were originally defined by the classified MOD document BR 3025[21] to include for *"Revised Emergency Reference Levels"* by selective sampling over which there is doubt relating to the accuracy and reliability of the techniques employed.

According to BR 3025, the MoD segregates its post accident monitoring into three stages:-

> **Stage I:** Measures the direct gamma shine from the submarine hull at a number of preselected monitoring points. Providing that the submarine is berthed this is likely to be undertaken automatically by the Dockside Installed Radiac System (DIRS). Some delays may occur if the submarine is not berthed and, particularly, where the hull shine is obstructed by another vessel or building.
>
> **Stage II:** Establishes whether a fission product release has occurred, to determine the direction of the release plume, local deposition of radioactive particles and if the release is continuing. Some part of this release monitoring is likely to be undertaken

21 BR 3025 (c1976) may now have been superseded and it refers specifically to NEMO (Naval Emergency Monitoring Organisation) – the BR documents are generally not available to organisations outside the MoD because permission for their release follows through a vetting system in which the sanction of a *'Sponsor'* is required but to determine if the documents are available, first, the documents have to be ordered so that the Sponsor may consider the request.

automatically by the Perimeter Monitoring System (PMS) but the ground contamination dose rates and smear samples will require NEMT health physics personnel involvement. In the immediate aftermath of the release, the Local Emergency Monitoring Team (LEMT) could undertake Stage II monitoring during the period of up to one hour that the mobile NEMT team has prepared and arrived on site.

Stage III: Determines the extent and magnitude of ground contamination in the public areas surrounding the Dockyard. Under Stage III checkpoints are located radially about the dockyard in 60° sectors, although in practice these follow the roads radiating from the Dockyard out to a distance of 20 to 30km.

The Clyde Plan provides no information whatsoever on how NEMT undertakes off-site monitoring, how it arrives at the dose exposures necessary to trigger the ERL countermeasures and, importantly, on how and in what form this information is to be passed to the civilian authorities. Unless the monitoring and dose assessment practices of BR 3025 have been substantially revised, then the monitoring must be confined to ground contamination so, it follows, gamma shine dose from the overhead release plume and thyroid dose for inhalation of the iodine content of the release must be extrapolated from the PMS, which may or may not have gamma spectrometry capability.[22]

In fact, monitoring activities immediately around the submarine or weapons accident site are likely to dominate the initial stages of the emergency response to any accident. This approach is set out in a Royal Navy training course on submarine reactor accidents:-[23]

"...

> *Stage III monitoring is started as soon as emergency monitoring teams (LEMO or NEMT) can be spared from Stage I or Stage II monitoring, or on the arrival of "back up" monitoring teams from CEGB, UKAEA etc. This should be some six hours or so after the initial report and may take several days to complete, depending on the number of teams that can be deployed for this task.*

..."

It is not at clear from the Clyde Plan how the appropriate countermeasures are to be implemented in the absence (*"six hours or so"*) of reliable radiological information being available.

THE CLYDE PLAN - CONCLUSION

This Review identifies and assesses the potential severity of i) a loss of coolant accident on board a Royal Navy nuclear-powered submarine when in the approaches to, manoeuvring within or berthed at any one of the Clyde berths; and ii) of a nuclear warhead accident occurring at the Coulport storage and explosives handling facility, or when in the silo of a Vanguard class of nuclear powered submarine.

The *Radiation Emergency Preparedness and Public Information Regulations* (REPPIR) require that the operator (here the MoD) identify *hazards* and evaluate the *risks* (*Reg 4*) and that there is to be *co-operation between the parties* (*Reg 8*) relating to the preparation and maintenance of emergency plans in which *the emergency plan shall be designed to secure the restriction of exposure to ionising radiation and the health and safety of all persons identified by the assessment* (*Reg 8*).

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23 *Reactor Accidents Course Notes*, Royal Naval College Greenwich, Department of Nuclear Science and Technology, 1992

The local authority (here Argyll and Bute) shall *prepare an adequate off-site emergency plan* (*Reg 10.1*) which *shall address each reasonably foreseeable emergency identified by the operator* (*Reg 10.2*) and *which shall be provided to the local authority by the operator* (Reg *10.4*).

Put simply, there is a duty placed upon the MoD to provide the local authority with sufficient information for that local authority to put in place adequate arrangements should a radiation emergency arise. The Clyde Plan is the local authorities response to *Regulation 10.1* that fails on the following key requirements:-

All Reasonably Foreseeable Emergencies

The types and severities of accidents reviewed here are considered to be reasonably foreseeable. Since both the *Category 3* submarine reactor plant accident and the nuclear weapons atmospheric radioactive release of plutonium are modelled and planned for by the MoD, it is surprising that these are not specifically cited in the Clyde Plan.

Because these two accident scenarios are not cited in the Clyde Plan the Plan, its organisational competency and identification of the human and equipment resources to be set aside would be unlikely to be effective in countering such an accident.

In this respect the Clyde Plan does not address each reasonably foreseeable emergency.

Adequacy of Off-Site Plans and Resources

In providing the radiological monitoring role, particularly as to where and how the initial monitoring is to be undertaken, the Royal Navy adheres to the pre-planned priorities of the MoD Book of Reference (BR) 3019. Yet, BR 3019 is not publicly available so it is not at all clear when and how, and to what effect, the public areas of the pre-planned countermeasure would be monitored.

Another publicly restricted BR document, BR3025, assigns least priority to monitoring of public areas since Royal Navy personnel are instructed to delay Stage III monitoring, viz *"Stage III monitoring is started as soon as emergency monitoring teams (LEMO or NEMT) can be spared from Stage I or Stage II monitoring, or on the arrival of "back up" monitoring teams."*

In other words, the Clyde Plan is overly dependent upon MoD personnel and resources monitoring the off-site sector and reporting and advising the local authority on when and what countermeasure to implement. If the accident is severe then MoD personnel are likely to be prioritised to the immediate locality of the accident, but a severe accident that requires early monitoring in the public areas if the consequences to the much larger public group are to be mitigated

The failure of the Clyde Plan to define the resources in terms of specific demands and the secrecy over how the resources available are to be prioritised raises a number of concerns over the readiness and effectiveness of the Clyde Plan.

Reliance of the Local Authority on the MoD

For the implementation of evacuation and all other countermeasures, the local authority seems to be overly dependent upon the MoD for radiological information and advice. This is particularly so for the pre-planned countermeasure zone where the countermeasures are triggered by the Royal Navy's assessment of the condition of the reactor fuel or nuclear weapon.

Reliable projection of the assessment of the condition of the fuel or the nuclear weapon to the radiological hazard that this represents to members of the public is absolutely critical in safeguarding public health and property. The procedures employed for this assessment,[24] and the means of communicating it through the MoD organisational structure to the local authority are not included within the Clyde Plan documentation and, in the main, are not publicly available.

This almost blind reliance of the local authority upon unpublished MoD procedures, criteria and judgements disqualifies the commanding role of the local authority in implementing its off–site emergency plan. Moreover, since there is no provision to check and corroborate the Royal Navy's decision-making until the involvement of the NRPB or Government representative, which will be several hours or more into the accident aftermath.

In effect, the Clyde Plan simply states that Argyll and Bute will implement emergency procedures and, other the most generalised statements of evacuation, sheltering and issue of PITs (which would not apply in a nuclear weapons accident), it remains totally reliant upon the MoD as to when and how it is to put in place actions that would mitigate the consequences to members of the public. This means that the Clyde Plan is totally tied to the MoD's plan for dealing with incidents and accidents within the boundaries of MoD establishments.

The problem here is threefold: First, the MoD is unlikely to publish its own emergency plans so the identification of the hazards and assessment of the risks remains concealed from the public. Second, the MoD plans will concentrate resources within the immediate area of the incident and will not extend, since it has no formal responsibility, far into the public domain, and it may not have assessed the manpower and equipment resources required to cover larger areas of population. And, third, the methods and criteria deployed by the MoD to assess and project forward radiation doses in the public sector are not publicly available and may, indeed, assume means of health hand risk assessment and valued judgements that would be unacceptable in the public domain.

In these important respects the draft Clyde Plan does not satisfy *Regulation 10* of the *Radiation Emergency Preparedness and Public Information Regulations* and, accordingly, the off-site emergency plans associated with nuclear powered submarines and nuclear weapons in Scotland should be subject to review to ensure that there is adequate protection for the local populations and the environment.

JOHN H LARGE
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24 The procedures are set out in a series of MOD documents (BR 3030 – Radiological Controls, BR 3020 Radiological Protection, BR 3019 Nuclear Reactor Accidents, BR3025 – Naval Emergency Monitoring Organisational Orders) none of which seem to be available in the public domain.