PHILOSOPHY OF MOD REACTOR ACCIDENT CONTINGENCY PLANNING

CONTENTS

Sponsor: Base Environmental Support Officer, Clyde Submarine Base

ILLUSTRATIONS

Annex

Page Blank

PHILOSOPHY OF MOD REACTOR ACCIDENT CONTINGENCY PLANNING

INTRODUCTION

1. The Royal Navy operates a number of nuclear powered submarines that form a vital element of the defence of the UK. The nuclear reactor offers the submarine a level of speed and underwater endurance that cannot be achieved by any alternative method of propulsion. Nuclear power is the only mechanism available to allow HM Submarines to carry out elements of the Navy's task in support of the UK's independent nuclear deterrent, anti-submarine warfare and in the protection of maritime supply routes.

2. The nuclear safety of naval reactors is given the highest priority and is independently assessed by safety and reliability experts from AEA Technology. In addition, the Secretary of State for Defence is advised on public safety by a specialist committee, the Nuclear Powered Warship Safety Committee (NPWSC), whose membership includes independent nuclear and radiation safety experts as well as those from within the Ministry of Defence (MOD) and other government departments. The prime contribution to nuclear safety comes from engineered safeguards, good design, quality in construction, training and competence of staff in operations and maintenance. Such measures ensure that the likelihood of a reactor accident occurring is extremely remote. Indeed during over 30 years of the Naval Nuclear Propulsion Programme there has never been a significant hazard to service personnel or a member of the public. Nevertheless it is MOD policy, in accord with UK statutory requirements and International Commission on Radiological Protection (ICRP) recommendations, to have in place detailed reactor accident contingency plans. These plans forming an additional level of public protection for use in the extremely unlikely event that an accident were to occur.

3. Ultimate responsibility for the Government response to a reactor accident would rest with the Prime Minister and Cabinet. The primary co-ordination role, however, would be taken by a pre-designated lead minister. For civilian power reactors this would be performed by the Secretary of State for Energy. For naval reactors the responsibility lies with the Secretary of State for Defence. Detailed central contingency plans exist for naval reactor accidents involving full co-operation between all relevant government departments. At the local level, MOD policy requires there to be an approved contingency plan developed in conjunction with local civil authorities at all berths cleared by the NPWSC for use by nuclear powered warships. The fact that it is a similar submarine reactor plant that uses each berth allows the production of a skeleton generic plan of the local accident organisation and response, which can be used in the production of site specific plans. Having a common basis, format and terminology in all naval reactor accident plans greatly facilitates the overall training of, and understanding by, response organisations both from within and outside MOD; and, hence increases the probability of the successful implementation of the plans in the unlikely event that an accident were to occur.

4. The common reactor plant and generic plan also allow the production of a single document providing all personnel who may be affected by a local plan with the same basic background information on naval reactors, reactor accident definitions and hazards, as well as the basis for and details of, the contingency plan. The required information is provided within Part 1 of BR (Book of Reference) 3019(1) - Nuclear Reactor Accidents, and is included, in total, as the first section of all local reactor accident orders.

REACTOR PLANT AND OPERATION

The Pressurised Water Reactor

5. A Royal Naval nuclear powered warship is driven by steam turbine machinery. However, unlike a conventional steam driven vessel, which uses fossil fuels to fire its boilers, the source of

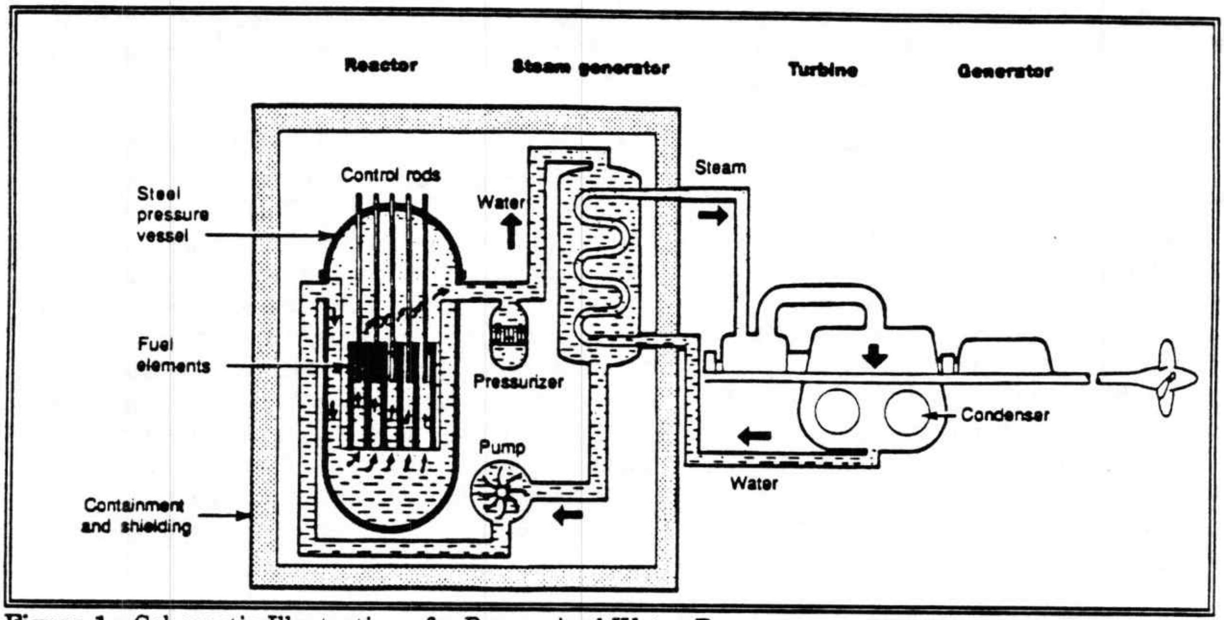

Figure 1 Schematic Illustration of a Pressurised Water Reactor

heat within a nuclear powered vessel is provided by a nuclear reactor. The type of reactor used is known as a Pressurised Water Reactors (PWR).

6. The reactor core contains fuel modules and control rods. To achieve criticality, the state in which the reactor is able to provide useful power, the control rods are slowly withdrawn from the core until the fission reaction becomes self-sustaining. The reactor is hut down by re-insertion of the control rods. The heat produced by the fission of the fuel is removed from the core by water contained in a sealed primary circuit. This water is circulated using coolant pumps through boilers where the heat is used to produce steam in a separate, secondary circuit. It is this steam that is used to provide power to the submarine. The primary circuit is kept under pressure to prevent the coolant water from boiling.

7. As well as heat, the fission process also produces radioactive fission products. Unlike some civilian power reactor designs where fission products can escape from the fuel modules and have been detected in the primary coolant, submarine fuel modules are contained in metallic cladding and there has never been an instance when fission products have been released from the fuel. Although the fission products remain contained in the fuel, the gamma radiation that they emit is highly penetrative and thus there is a need for shielding to be fitted around the core and to be built into the submarine's reactor compartment. The shielding installed in RN nuclear powered submarines reduce the radiation levels within the manned compartments of the submarine so that the average levels of radiation dose to members of the crew, from reactor operation, are less than the average natural background levels received by the UK population.

8. The heat produced by the fission process would be sufficient to melt the fuel modules if they were not cooled. To overcome this the submarine design incorporates a number of mechanisms that are able to supply cooling to the reactor. These include natural convection so that cooling would continue even on complete loss of electrical power.

Reactor Containment

9. Following an accident the potential hazards associated with nuclear reactors would come from the release of fission products outside the fuel. As already stated submarine reactor fuel is encased in strong cladding, but beyond this protection there are a number of other barriers designed to contain the fission products. Should the cladding fail, the primary coolant system, which is a closed circuit, would contain the fission products and prevent further spread.

1Ø. Beyond the primary coolant system, the submarine's reactor compartment is designed and constructed to meet the severe rise in pressure that could be associated with the very unlikely event of a complete failure of the primary system. This barrier to the release of fission products is

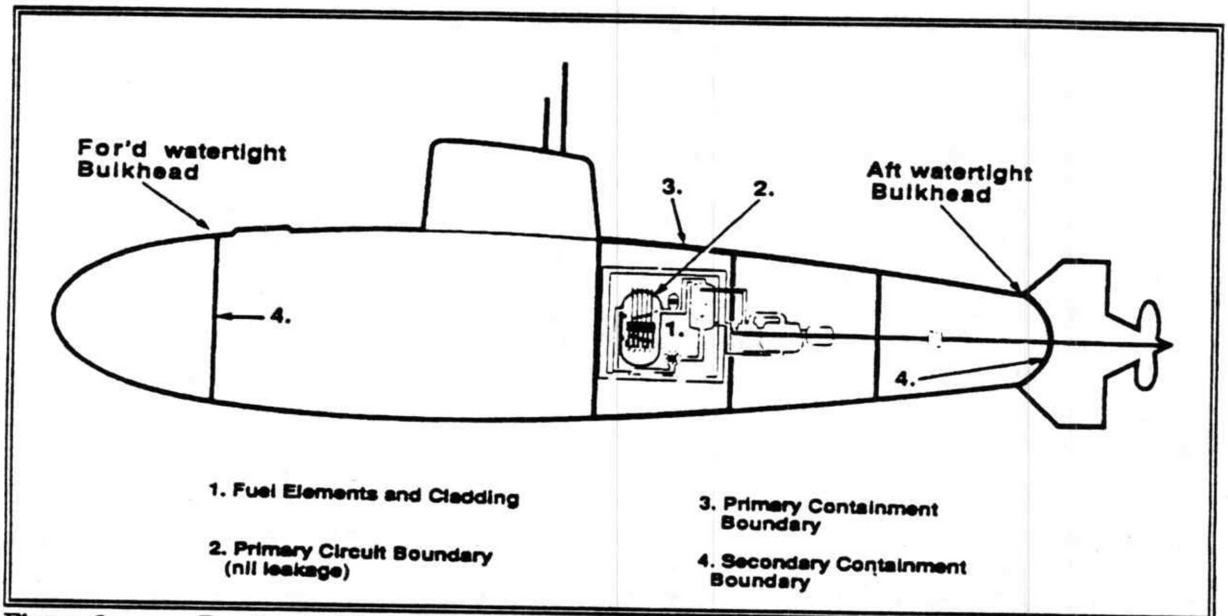

Figure 2 Barriers to Fission Product Release

termed Primary Containment. Pipes, ducts and other penetrations between the primary containment and the remainder of the submarine are designed to be shut off automatically. Even if these openings were to allow a slow release of a proportion of fission products these would still be contained by the immensely strong hull of the submarine, which is designed to withstand the enormous pressures associated with operations at depth. The submarine's pressure hull is referred to as Secondary Containment.

REACTOR ACCIDENTS

Definitions

11. It is impossible for an accident in a naval pressurised water reactor to result in a nuclear explosion. The only reactor accident that can result in a hazard to personnel outside the nuclear warship is one which leads to a release of the fission products normally retained within the reactor core. A nuclear Reactor Accident is defined as:

> "An unexpected event which is likely to lead to, or has resulted in, a release of fission products external to the fuel".

This general definition is sub-divided into 3 categories of accident, which would be used to provide, in shorthand form, further information on the accident severity in the unlikely event that one were to occur.

a. Category 1 - an event that is likely to, or has resulted in, the release of fission products from the fuel.

b. Category 2 - an event that has led to a radiation hazard as the result of the release of fission products from the fuel.

c. Category 3 - an event that has led to the release of fission products, from the fuel, to the environment outside the pressure hull.

12. These categories are related to the functioning of reactor containment. The Category 1 definition allows for the precautionary implementation of contingency plans in a period before any hazard exists. It also refers to a situation where fission products remain contained within the primary circuit. Category 2 accidents have an associated hazard, but, since fission products are not being detected outside the pressure hull, the definition relates to the effectiveness of primary and secondary containment. The definition of a Category 3 accident states clearly that a release of fission products outside the submarine has occurred. While it is convenient to discuss accident types in terms of accident Category, in the remote possibility that a severe accident were to develop, it should be recognised that the Category could change with time as the accident progressed, or as more information became available. A Category 1 report might refer to an initial event which is followed by a Category 2 report as a hazard inside the submarine is detected, then Category 3 as monitoring outside the vessel detected that a release had occurred. It is MOD policy that the local plan, including the implementation of automatic countermeasures (Para 32b) should be instigated in full following the declaration of a reactor accident irrespective of Category.

Accident Probabilities

13. As part of the Naval PWR design safety justification to ensure that all reasonably practical measures have been taken to prevent accidents, detailed analyses are carried out into the mechanisms by which a reactor accident could be initiated, and the performance of the many safety systems. The results of such analyses provide quantitative estimates of the probability of accidents and their consequences in terms of the magnitude of any release of fission products into the environment. The results of this work are independently assessed and then endorsed by the NPWSC.

14. The various accident analyses are combined to provide a detailed assessment of reactor accident risks that demonstrates that the most severe accidents have by far the lowest probability of occurrence. In common with ICRP recommendations to ensure that plans should consider a wide range of potential scenarios, including those having a low probability of occurrence, it is the assessed consequences of the full range of naval reactor accident scenarios that are used to evaluate the performance of the MOD contingency plan. In this respect the MOD plan differs from those adopted for civilian power plants which are based on a single specified "Reference Accident". To provide some indication of the scale of submarine reactor accidents, it is assessed that the worst case event predicted to occur at about once in ten thousand years of reactor operation, should not require the emergency evacuation of people beyond 550 metres from the accident submarine. More severe accidents involving the failure of primary containment have a predicted probability of occurrence of about once in a million years of reactor operation.

HAZARDS OF A REACTOR ACCIDENT (Figure 3)

Biological Effects of Radiation

15. It is the ionising radiation given off by the fission products that would pose the hazard following any reactor accident. As radiation passes through the human body, ionisation events occur which may damage or kill cells. The body is of course being subjected continuously to natural background radiation and has well developed repair processes to deal with radiation

damage. Different human cell types have very different radiation sensitivities but if the radiation dose is great enough and large numbers of cells are killed, signs and symptoms of acute radiation exposure would appear. These acute radiation effects include skin burns and most severely death, but all have a defined threshold of dose below which the effect will not take place.

16. At radiation doses below the thresholds, acute effects cannot occur, though cells may have been damaged with the result that individuals exposed have a statistically increased risk of the development of cancer in years to come. Reproductive cells may also have been damaged so that children born to those people exposed may have an increased risk of hereditary defects. For radiation protection purposes, the increased risk of these effects is assumed to be directly proportional to the radiation dose, without any threshold.

Radiation and Contamination

17. To understand the hazards of a reactor accident, it is important to appreciate the meaning of and differences between the terms radiation and contamination. Even in a situation where the fission products remain contained, the penetrating radiation that they give off may still irradiate people nearby. Protection against such a hazard would be afforded by reducing the time people spent close to the fission products, placing shielding between the individuals and the radiation source or increasing the distance between them and the source. This is termed a radiation hazard. If, however, personnel became contaminated with fission products, either on the surface of their body or internally by breathing, eating or drinking, then the subjects carrying the source of the radiation around with them would continue to be irradiated until that source was removed. This termed a contamination hazard.

The Hazards

18. Following a severe reactor accident involving the release of fission products outside the primary circuit, there are 2 distinct ways by which people could be irradiated:

a. Gamma radiation from fission products retained within the submarine containment would be transmitted in all directions through the vessel's hull. The intensity of this pure radiation hazard would be diminished by both shielding and distance from the submarine, but excessive levels of radiation could be received by people within, or in proximity to, the vessel. This hazard is referred to as Gamma Shine.

b. Less likely is the release of some of the fission products from the submarine to the surrounding atmosphere or water. With the release of the fission products, the actual source of the radiation, a contamination hazard would exist.

Release of Fission Products to Atmosphere (Figure 3)

19. If released to atmosphere the fission products would be dispersed in the area downwind of the vessel. The extent of any hazard and the distance to which such a fission product cloud could be detected would be highly dependent on the weather during the period that the release took place. Such a cloud of radioactive contamination could irradiate people in 5 distinct ways:

a. Direct radiation from the cloud as it passes by.

b. By inhalation of radioactive fission products from the cloud. The parts of the body receiving the greatest radiation doses would depend on the chemical and physical form of the individual fission products. It is possible that a significant dose could result from the inhalation of radioactive iodine that is readily absorbed and concentrated in the thyroid gland. Another group of fission products in insoluble form, would remain in the lung. A third main group would be readily absorbed but are not concentrated particularly in any organ.

c. Direct radiation from fission products that have been deposited on the ground. This route like the above would result in fairly uniform whole body radiation exposure.

d. Inhalation of fission products that have been resuspended after deposition on the ground. This route has been shown to be insignificant compared with doses that would result from b. and c.

e. Consuming food or drink which have been contaminated by fission products. As a radioactive cloud moves downwind, some of the radioactive fission products could be deposited onto the surface of food, either growing in fields or lying open on market stalls, etc. This superficially contaminated food would cause internal contamination to those who consumed it in the immediate post accident period. Fission products deposited on the ground may also be taken up by growing plants and animals that may be eaten by man with the resultant internal contamination and radiation dose. The contaminated plants and animals may not be eaten directly by man, but may enter a food chain and pass through a number of stages before entering the human diet. It is probable that radioactive iodine would lead to a significant proportion of doses arising from contamination of pasture. Iodine deposited on grass could be concentrated in the milk of grazing dairy animals and hence pose a hazard if the milk was drunk. Peak levels of radioactive iodine in food would be reached 2 days after the release with levels decaying over the next several weeks. After the decay of the iodine, the dominant hazard by the ingestion route would be the take-up of longer lived fission products into the food chain.

20. In the very unlikely event of a release to atmosphere the principal short term hazards would be direct irradiation from the cloud, inhalation of fission products and radiation from ground deposition. Food chain contamination although representing less of a hazard initially, would become of increasing significance in the longer term.

Release of Fission Products to Water

21. The radiation effects from fission products released to water would be highly dependent on the state of the tide and the characteristics of the estuary into which the release took place. There are 4 ways in which people would receive a dose of radiation following such a release:

a. Direct radiation from the water either to those immersed within it or to those in its immediate vicinity.

b. Ingestion of the water.

c. Irradiation from the deposition of fission products on banks and areas uncovered by the tide.

d. Fission product contamination of marine food chains.

22. Following a reactor accident, the immediate radiation hazards to the population resulting from a fission product release to water would be very small in comparison with the same release to atmosphere. The hazards would be confined to the area around the water's edge and the release would be continuously dispersed and diluted. Food chain contamination could become of increasing significance in the longer term.

PROTECTION OF THE PUBLIC FROM THE HAZARDS OF A REACTOR ACCIDENT

Accident Management

23. If a reactor accident were to occur, emergency procedures would be followed by the submarine crew and engineering support, with the aims of preventing or minimising core damage,

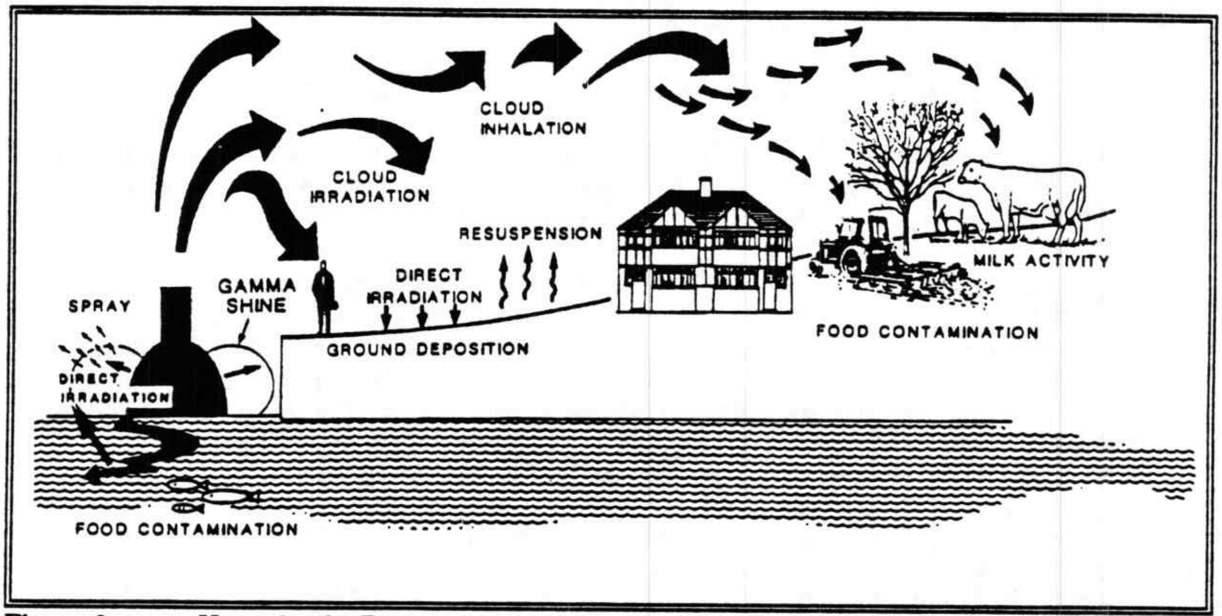

Figure 3 Hazards of a Reactor Accident

maintaining the integrity of containment and minimising any release of fission products. This accident management strategy would form an important element in the overall protection of the public.

Emergency Countermeasures

24. The entire population of the UK is constantly exposed to naturally occurring radioactivity, however, as a rule the levels of this radiation are so low as to be considered insignificant. In the event of a radiological emergency, increases in this background radiation would result and probably continue unless some forms of intervention were to take place. For a serious accident, intervention in the form of emergency countermeasures that are implemented population-wide in the surrounding area, could be required. Since the implementation of widespread countermeasures, even according to a preplanned scheme, is not a risk-free activity, it follows that there must be some criteria on which to base any decision to take such measures following a reactor accident.

25. The development of criteria for the implementation of emergency countermeasures following a reactor accident should be based on the principle that countermeasures are to be introduced if they would achieve more good than harm, and that introduction and withdrawal of measures should be aimed to provide optimum protection. Although the measures would be taken population wide, it is the risk to the individual that is considered of greatest importance in determining the need for emergency countermeasures. The basic requirements for implementation criteria are as follows:

a. Countermeasures should be introduced to ensure no individual suffers acute effects of radiation for which there is a threshold.

b. The increase in probability of the individual suffering cancer or hereditary effects from radiation exposure should be balanced against the detriment from the countermeasure itself to determine the optimum protection of the individual.

26. Within the UK, guidance on emergency countermeasures to protect the public following nuclear accidents is provided by the National Radiological Protection Board (NRPB). Basic methods of reducing radiation exposure such as time, distance and shielding are still relevant in the mass countermeasure situation but they are incorporated into three countermeasures that may be applicable to implementation to a population:

a. Sheltering The public remaining indoors with doors and windows shut.

b. Stable Iodine Administration if stable iodine (non-radioactive) is taken before or within a few hours of internal contamination with radioactive iodine, then the resultant radiation dose to the thyroid gland would be reduced substantially.

c. Evacuation In the context of nuclear accident contingency planning, the term evacuation refers to the movement of people out of an area as a countermeasure implemented in emergency. At the time of implementation little consideration is given to how long people may have to be away from the locations from which they are evacuating. If carried out before the existence of any hazard, evacuation would prevent almost all the radiation exposure that would have resulted. The adverse effects and difficulties of population evacuation however, are significantly greater than for shelter.

27. The NRPB also recommends dose criteria for the implementation of these emergency countermeasures in an accident situation. The intervention levels are known as Emergency Reference Levels (ERLs) and are presented in terms of the dose to an individual that would be averted by taking the relevant countermeasure. ERLs are specific to each countermeasure because the detriment associated with each countermeasure is different, and are promulgated as a range between two specified values. If doses that can be avoided by the measure are below the lower level for that measure, then the NRPB advises that the countermeasure should not be introduced because it would be unlikely to be justifiable. If doses that could be avoided are estimated to exceed the upper level, then the NRPB would expect every effort to be made to introduce the measure.

28. In addition to the promulgation of ERLs the NRPB also recommends consideration of precautionary actions, that is to say automatic implementation of countermeasures without waiting for information on the extent of the hazard, and states that it is important to determine specific intervention levels for use in specific countermeasure plans.

29. In considering emergency countermeasures following a release of radioactivity to, the environment, it is important to recognise that radiation exposure or the extent of contamination does not necessarily stop at the distances to which countermeasures have been implemented. It is simply that extension of emergency countermeasures beyond the implementation distance would not be justified and, indeed, could pose more of a threat to the public than the radiation dose they are intended to avert.

Other Countermeasures

30. In addition to emergency countermeasures for which ERLs are promulgated, other measures may be applicable to protect the public following a reactor accident.

a. Food Controls In the UK the public would be protected from the hazards of fission products in food or water by the control and disposal of the contaminated material. Intervention levels for food are promulgated by the European Commission and are very low being based on doses that individuals would receive if they consumed such food for a year following the accident. It is probable, therefore, that in the event of a reactor accident which did release fission products, food and farm restrictions could extend to distances significantly greater than those to which emergency countermeasures have been taken.

b. Relocation Relocation, as distinct from evacuation, which is an emergency measure, is the term used to describe the movement of the public from contaminated areas to avoid long term radiation exposure or to allow decontamination to take place. There are no national criteria for the implementation of this measure. Any decision regarding relocation would be on the basis of local government discussion together with relevant national bodies such as the NRPB with the aim of optimising the protection of the public. The protection provided by adequate emergency countermeasures would allow the required time to assess the need for relocation.

NAVAL REACTOR ACCIDENT CONTINGENCY PLANNING

Aims of the Naval Plan

31. The Naval reactor accident plan includes automatic and pre-planned response actions to mitigate the consequences of an accident and to protect the public to standards which accord with national guidance. In addition the plan involves the establishment of the required command, control and liaison organisation, at local and national level, capable of the successful implementation of these early measures. This organisation allows consideration, by all relevant authorities, of the later follow-on and recovery aspects of the accident for which detailed pre-planning is not considered appropriate.

Planning Zones

32. The basic Naval reactor accident plan used at all berths cleared for use by nuclear powered warships specifies 3 zones where differing actions would take place in the event of an accident.

a. The Exclusion Zone The Exclusion Zone is an area including the submarine itself in which people would be at greatest risk from the hazards of an accident. The size of this zone varies with local plans but the most basic consideration in its identification is that people within it, even if they took immediate automatic countermeasures, could still receive radiation doses above the upper ERL for evacuation. Within this zone, all people are accounted for and are provided with equipment by which their radiation dose can be assessed. The local plan must provide for an Exclusion Zone reception centre where personnel evacuating from the zone would have access to medical, radiation protection, monitoring and decontamination facilities. Stable iodine, in the form of Potassium iodate is also to be provided at the reception centre.

b. The Automatic Countermeasures Zone beyond the Exclusion Zone is the Automatic Countermeasures Zone. Within this area all people not essential to the management of the accident would be evacuated and supplied with Potassium iodate tablets. Automatic actions would commence immediately on declaration of an accident, irrespective of category. In a number of local plans, automatic countermeasures include initial shelter within pre-designated shelter areas followed by a controlled evacuation. All people living or working within this zone should be given instructions on what actions they should take in the event of an accident. The extent of the automatic countermeasures zone is set at a distance of 550 metres from the submarine in all directions (as a management prerogative 600 metres has been chosen in the Clyde Submarine Base as being a suitable distance for planning purposes). Automatic measures provide the great advantage of early and perhaps, complete public protection if they are in place before the existence of the hazard. The distance to which they are planned however, must represent a balance between this possible benefit and the detrimental effects resulting from their implementation for the more probable accidents producing either no hazard or hazards that would not require measures to be taken to such a distance. The approximate frequency of accidents for which the upper ERL for evacuation would be exceeded beyond the 550 metre distance is assessed to be once in every half a million years of continuous reactor operation.

c. Preplanned Countermeasures Zone Assessments of the likely consequences of reactor accidents demonstrates that emergency countermeasures would only be required beyond the Automatic Countermeasures Zone downwind from the accident submarine and in the very improbable event of a larger release of fission products to atmosphere. Advice on the need for these measures would be based on the technical assessment of the way in which the accident was developing and on an assessment of doses to the public obtained from monitoring information. The Naval plan requires there to be a local pre-arranged monitoring scheme and for consideration to be given how emergency measures could be implemented in an area designated the Pre-planned Countermeasures Zone. The zone extends around the Automatic Countermeasures Zone, and while the zone itself is designated in all directions around the berth. Following an accident it is assumed that monitoring and any countermeasure requirements would be confined to the downwind areas. The Pre-planned Countermeasures Zone includes a number of distances applicable for various planning activities. The overall zone extends 10 kilometres from the submarine and 2 kilometres is specified as the extent to which plans for the issue of Potassium iodate should be made. The approximate frequency of accidents in which an upper ERL for any

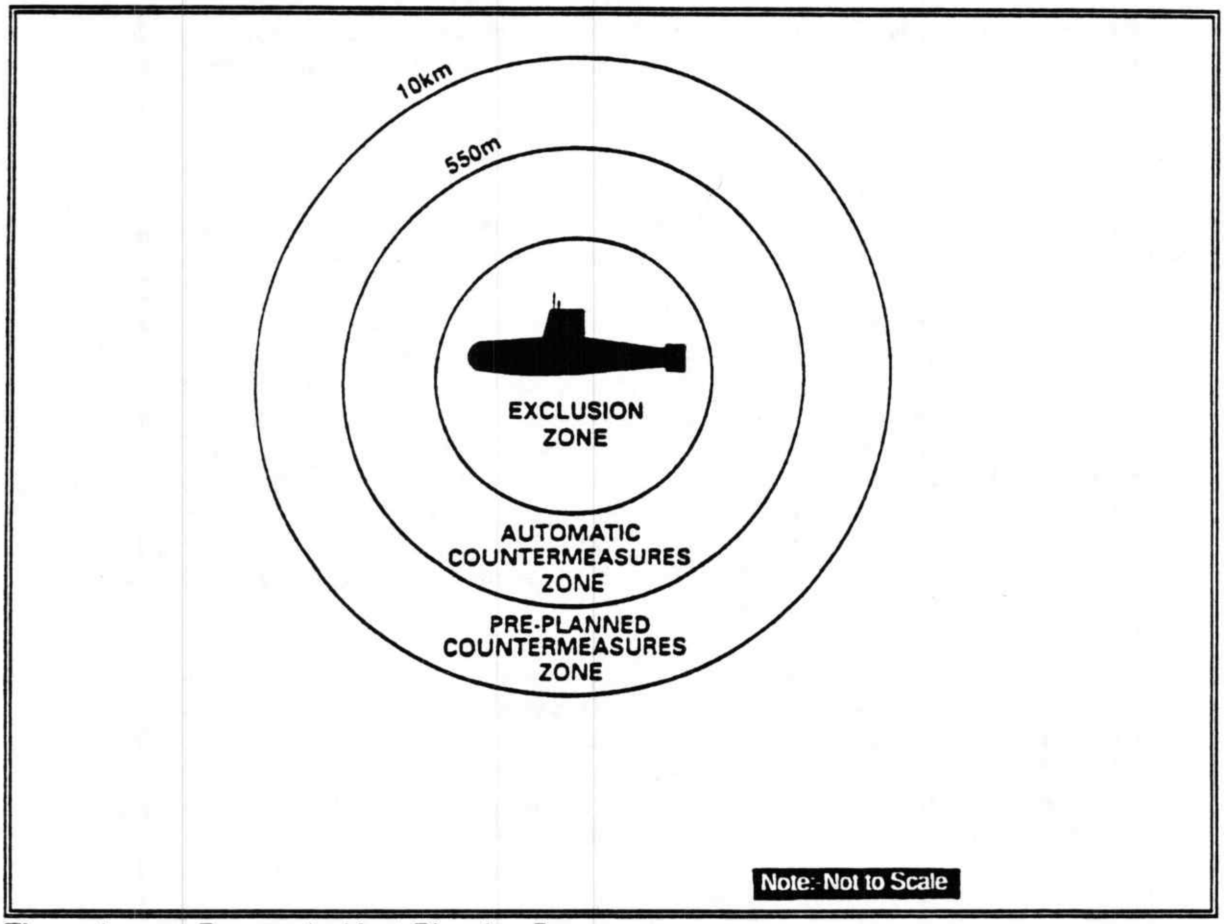

Figure 4 Reactor Accident Planning Zones

emergency countermeasure would be exceeded beyond 10 kilometres is assessed at once every million years of continuous reactor operation.

Beyond the Pre-planned Countermeasures Zone the probability of a requirement for emergency countermeasures is so remote that specific Naval; reactor accident contingency plans for emergency public protection are not required. At these distances the main considerations would be possible monitoring for pasturage contamination and of food stuffs.

Emergency Action Guidance Levels

33. The requirement for, and extent of, countermeasures within the Pre-planned Countermeasures Zone would be based on a comparison of projected individual doses with Emergency Action Guidance Levels (EAGLs). Like ERLs, EAGLs refer to the dose that can be averted by taking the countermeasures. EAGLs are specific to Naval reactor accident plans, and fall within the ERL range. Numerical values for the EAGLs have been derived from a detailed assessment of the likely impact of a range of postulated submarine accidents. The levels are endorsed by the NPWSC and monitoring procedures are designated to assess doses in a format that facilitates direct comparison with the EAGLs.

Berthing Policy

34. The requirements to maintain nuclear safety and for there to be a site specific local accident plan, determine that all berths used by nuclear powered warships require to be assessed and their use approved by the NPWSC. Berth Assessment examines the safety aspects of navigational hazards, provision of tugs and other facilities and the existence of any other hazards in the local area. Because there must be effective evacuation of persons from the Automatic Countermeasures Zone, berths are chosen so that few members of the general public live within that area. Special consideration is given to the proximity of public utilities such as schools and hospitals.

35. Berths cleared for use by nuclear powered warships are categorised in terms of their use.

a. X Berths X Berths are cleared for the building, commissioning, refitting, refuelling or defuelling of nuclear powered submarines or for the repair and maintenance of the nuclear plant together with tests and trials.

b. Z Berths Z Berths are cleared for operational or recreational visits by nuclear powered warships. These berths are not cleared for the maintenance or repair of the nuclear plant.

36. During all periods when a nuclear powered submarine is at a UK cleared berth there is a requirement for a number of personnel to be in the area. These specialists will either be part of local Naval Base Organisations or collocated at the berth for the duration of the visit. They are:

a. An element of the Naval Emergency Monitoring Organisation (NEMO), able to carry out monitoring in the event of the accident. The activities of these monitors are co-ordinated through a pre-designated Emergency Monitoring Headquarters (EMHQ) which may be either mobile or static.

b. A qualified professional Health Physicist who is able to advise on the need for emergency countermeasures.

Elements of the Local Nuclear Accident Organisation

37. A Nuclear Accident Response Organisation (NARO) is established in all ports containing nuclear cleared berths, with the primary function of safeguarding the Service and civilian workforce and the local population in the event of a reactor accident in a nuclear powered warship. While the detailed composition of the NARO has some variation between sites, the key elements of the organisation remain the same.

38. The principal Naval elements of the NARO are the Military Co-ordinating Authority (MCA) and the Incident Commander (IC), both supported by teams providing advice on health physics, monitoring, public information and technical matters. The MCA is in overall administrative control of the post accident procedures and reports directly to the MOD central organisation, and thence to the Cabinet and Prime Minister.

39. The MCA delegates responsibility to the IC for the control of the immediate situation on site, including the implementation of the automatic countermeasures and the continuing process of accident management. Within a Naval Base, this would be an almost total Naval function and the MCA and IC headquarters are normally combined to form a Nuclear Accident Headquarters (NAHQ). Within civil ports the IC forms the naval element in an organisation that includes the Port Authority and Emergency Services, termed the Port Safety Panel, which would co-ordinate this on-site role.

40. While receiving reports from the IC, the MCA co-ordinates the post accident response outside the Automatic Countermeasures Zone. He is responsible for liaising with local and national civil authorities and providing them with all relevant information. He is also responsible for the co-ordination of the local media response. A key element of the MCA role is advice to the police and to the local health authority on the need for emergency countermeasures. To provide independent validation of MCA advice, a senior member of NRPB staff will go immediately to the MCA headquarters. Another NRPB staff member is also included within the central organisation.

41. In addition to the Naval response to a reactor accident, the local plan co-ordinates the responses of civil authorities, a number of which have statutory roles to carry out. These groups include the police, fire and ambulance services, the local health authority, water authority and the local authority itself. In addition to these bodies there are also the local or regional representatives of central government departments such as the Ministry of Agriculture Fisheries and Food, Scottish Office, Welsh Office and Her Majesty's Inspectorate of Pollution. The local plans drawn up in consultation with all these bodies reflect their requirements and in most cases the authorities are collocated together in the Local Accident Headquarters (LAHQ) (variously titled Local Action Headquarters, Local Authority Headquarters). There is a clear requirement for good communication between the MCA headquarters and the LAHQ, and both authorities should exchange liaison representatives to facilitate exchange of information.

Liaison with Local Authorities and Public Information

42. Plans for the protection of the general public must be prepared allowing for full consultation with local authorities. This is facilitated by forming Local Liaison Committees (LLCs) which are formed at all X and Z berths in UK and Gibraltar. However:

a. In places where there are Z berths and where contact between Naval authorities, civil emergency services and local authorities confirm the civilian view that such a committee is not required, a LLC need not be formed.

b. In certain areas, such as the Highlands and Islands of Scotland, a single LLC may apply to several berths.

43. A LLC should consist of naval authorities, local authority representatives, emergency services representatives and local representatives of central government departments. Its purposes are:

a. To inform the public on the scale of the hazards involved in operating nuclear submarines.

b. To produce and review local plans for the protection of the population in the unlikely event of a serious accident.

44. LLCs should meet at least annually but members may request the Chairman to call meetings at a greater frequency.

45. Local safety plans are required to be submitted for approval to the Commander-in-Chief Naval Home Command. Public safety plans are to be unclassified documents and, once approved, they should be made available to the public, normally by their placement in public libraries by local authorities.

Exercise Policy

46. It is Ministry of Defence policy that reactor accident response plans should be exercised regularly.

Claims for Injury, Damage or Loss

47. In the very unlikely event that a reactor accident did occur, injury, damage to property and other financial difficulties for members of the public could result. The Ministry of Defence will deal with claims under the principle for nuclear injury and damage (including the sole and absolute liability of the operator) established by the Nuclear Installations Act 1965; the Act does not apply to nuclear vessels, but claims will nevertheless be dealt with according to the same principles. The Ministry of Defence is prepared to consider any reasonable claim for compensation for loss or damage that can be shown to have been directly attributable to the incident concerned. Each claim will be considered on its merits, taking into account the full circumstances surrounding the incident. Any claim received will be dealt with expeditiously but no fixed timescale can be given in view of the wide and varied nature of any likely claim.

Page Blank

ANNEX A

GLOSSARY OF TERMS

AUTOMATIC COUNTERMEASURES ZONE
An area extending to at least 550 metres from the berth in all directions, within which countermeasures will be taken automatically on declaration of an accident.

BECQUEREL (Bq)
Unit of amount of radioactivity,
1 Bq = 1 disintegration per second

CHAIN REACTION
A process that, once started, provides the conditions for its own continuance. In a reactor, neutrons released in the fission process cause further fission, and so on.

CLADDING
The metal sheath within which the reactor fuel is sealed.

CONTROL ROD
Rod of neutron absorbing material inserted into the reactor core to soak up neutrons and either shut down or reduce the rate of fission reaction.

CONTAINMENT
Primary Containment
The compartment surrounding the reactor plant made up of the pressure hull of the submarine and internal bulkheads designed to withstand the build up of pressure after a severe reactor accident.

Secondary Containment
The compartment within the submarine hull on either side of the primary containment that can prevent internal leakage from primary containment to the atmosphere.

CONTAINMENT STATE
The state of integrity of the various containment boundaries within the submarine.

CORE
The region of a reactor containing fuel within which the fission reaction is occurring.

CRITICAL
A reactor is defined as critical when the fission chain reaction is in a controlled self-sustaining state and hence maintains power output from the reactor at a constant level.

CURIE
Old unit of amount of radioactivity. Now superseded. See BECQUEREL.
1 Curie = 3.7×10^{10} BECQUERELS.

DECAY HEAT
Heat produced by any radioactive decay, particularly of fission products, in the reactor fuel. This continues to be produced after the reactor has been shutdown. It cannot be shut off, but gradually dies away after the reactor has been shut down.

DECONTAMINATION	The removal of radioactive material from a person or surface.
DOWNWIND SECTOR	Normally refer to the sector 15° either side of the prevailing wind direction downwind of the accident site.
EMERGENCY ACTION GUIDANCE LEVEL (EAGL)	Radiation dose selected from the ERL range at which a particular countermeasure would be instituted within Naval reactor accident plans.
EMERGENCY COUNTERMEASURES	Measures consisting of shelter, evacuation or the administration of stable Iodine that may be instituted to protect the public in the emergency phase of a reactor accident.
EMERGENCY REFERENCE LEVELS (ERLs)	A range of intervention levels of dose advised by the NRPB providing guidance on the need for emergency countermeasures following a nuclear accident.
EVACUATION EXCLUSION ZONE	A special control area for personnel, established in the immediate vicinity of the NPW.
FISSION	Disintegration of a nucleus into two lighter fragments (known as fission products) plus free neutrons - either spontaneously or as a result of absorbing a neutron plus energy.
FLASHING UP } PULLING RODS } STARTING UP }	Terms often used instead of 'GOING CRITICAL'.
FUEL	The enriched Uranium fabricated for use in the core.
GAMMA RADIATION	High energy electro-magnetic radiation of considerable penetrating power emitted by most radioactive substances.
GAMMA SHINE	The gamma radiation that would emanate directly from a submarine following a reactor accident.
GOING CRITICAL	The process of withdrawing control rods to increase the rate of fission, hence power, until the self-sustaining condition is reached.
HALF LIFE	Period of time within which half the nuclei in a sample of radioactive material undergo decay.
MELTDOWN	In a severe accident melting of the fuel elements within the core.
NEUTRON	Uncharged sub-atomic particle, constituent of nucleus - ejected at high energy during fission, capable of being absorbed in another nucleus and bringing about further fission.

PLANT STATE	Refers to the pressure and temperature state of the reactor.
POTASSIUM IODATE TABLETS (PITs)	Tablets containing stable (ie non-radioactive) Iodine that would minimise the uptake of radioactive Iodine into the thyroid gland.
POWER RANGE TESTING (PRT)	A series of tests carried out after initial criticality of a new core and designed to provide assurance of its integrity at all power levels.
PRE-PLANNED COUNTER-MEASURES ZONE	An area extending in all directions from the boundary of the Automatic Countermeasures Zone to a distance of 10 kilometres from the berth. Within this area contingency planning is required to facilitate monitoring and to allow the implementation of countermeasures in the area of the zone downwind of the NPW.
PRESSURISER	Electrically heated boiler in the primary coolant system that boils water as necessary to maintain coolant pressure by means of a steam bubble.
PRIMARY CIRCUIT	The pipework containing primary coolant connecting the reactor pressure vessel to the steam generator.
PRIMARY COOLANT	Water that is pumped through reactor core to remove heat generated there.
RADIATION (Ionising)	Neutrons, alpha or beta particles or gamma rays that can emanate from radioactive substances.
RADIOACTIVITY	Behaviour of substance in which nuclei are undergoing transformation and emitting radiation. It is measured in Becquerels, ie the number of nuclear disintegrations per second.
RADIATION DOSE	<u>Absorbed Dose</u> - Energy imparted by radiation to unit mass of tissue. Unit: Gray (Gy) (formerly expressed as RAD). <u>Dose Equivalent</u> - Absorbed Dose weighted for harmfulness of different radiations. Unit: Sievert (Sv) (formerly expressed as REM). <u>Effective Dose Equivalent</u> - Dose Equivalent weighted for susceptibility to harm of different tissues (risk weighting factors).
REACTOR CRITICAL	This is the normal operating state of the reactor with the control rods withdrawn sufficiently to give a stable neutron population and fission rate.
REACTOR PRESSURE VESSEL	The large container surrounding the reactor core.

RELOCATION	The movement of members of the general public away from contaminated areas to avoid chronic long term radiation dose.
SCRAM	Rapid shutdown of fission process in reactor by inserting control rods.
SECONDARY CIRCUIT	The system that takes steam from the steam generators to the turbines and returns feed water.
SELF-SUSTAINING	The condition where the reactor is critical and is meeting the electrical demands of the submarine.
SHIELDING	Material that attenuates radiation, ie reduces its intensity. Different materials provide effective shielding against different types of radiation.
SHORE SUPPLY	An electrical supply to the submarine derived from a shore system and used to supply the submarine with electrical power when the reactor is shut down.
SHUTDOWN	The reactor state when all the control rods are fully inserted and the neutron chain reaction has ceased.
STEAM GENERATOR	Boiler in which hot primary coolant from the reactor core raises steam in a separate secondary system to drive propulsion machinery and turbogenerators.
SUB-CRITICAL	A reactor is sub-critical when the fission is insufficient to maintain a self-sustaining chain reaction.