BERTHS FOR NUCLEAR POWERED SUBMARINES IN SCOTLAND

- A CRITIQUE OF PUBLIC SAFETY SCHEMES

INTERIM REPORT

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1. INTRODUCTION

In Scotland there are many naval bases, deep water lochs and bays that are visited by, or have some other connection with, British and United States nuclear powered submarines.

As these submarines are powered by nuclear reactors, special precautions are needed to ensure that the chances of an accident are kept to a minimum, and that, if an accident does occur, protective measures are in place to cope with it.

In an attempt to meet these requirements, public safety/special safety schemes and Nuclear Safety Orders have been established by the Royal Navy. There are three in place to cover berths for nuclear powered submarines in Scotland. These are:

(1) 'The Clyde Area Public Safety Scheme' (ClydePubSafe)
(2) 'The Scottish Special Safety Scheme' (ScotSpecSafe)
(3) 'The Rosyth Public Safety Scheme' (RosPubSafe).

The primary aim of these public safety schemes is:

> *... to define the procedures which would be adopted by the Naval and Civil authorities to safeguard members of the general public in the unlikely event of a nuclear reactor accident in a nuclear powered warship ...* (1)

They were all written with the aid of the 'MoD Navy Nuclear Reactor Accident Reference Book' (currently undergoing rewrite). All were set up in liaison with local authorities, the emergency services, and numerous other bodies concerned with public safety.

SECTION 1

BERTHS FOR NUCLEAR POWERED SUBMARINES IN SCOTLAND

- A CRITIQUE OF PUBLIC SAFETY SCHEMES

INTERIM REPORT

2. THE SCOPE OF THE PUBLIC SAFETY SCHEMES IN SCOTLAND

The public safety schemes outline two types of reactor accident that may occur (see Chapter 4, 'Types of accident and risk estimates'), list individuals and office-bearers and their responsibilities, and outline countermeasures to be taken in the event of an accident.

The countermeasures specifically mentioned include:

(1) the immediate evacuation of all non-essential personnel from a radius of 550 metres around the accident site
(2) the distribution of potassium iodate tablets to all personnel who were within the 550-metre zone, and, if necessary, to members of the general public living inside and outside this zone
(3) the control of the sale and consumption of contaminated milk and other foodstuffs within a 9 kilometre radius of the scene of an accident
(4) the possible evacuation of the general public from certain areas within 1 or 2 kilometres from the scene of an accident.

> *The scheme is a guide to the kind of action which might be required by both Naval and Civil authorities after a nuclear accident message is received. Broadly, it might involve evacuation of personnel within 550 metres (including the submarine crew), sheltering and the issue of Potassium Iodate tablets. In addition milk restrictions for a short period over an area of approximately 9 km radius as well as restrictions on the consumption of exposed vegetables, fruit, free range eggs and unsealed food and liquids within 1.5 Km radius of the accident will have to be considered.* (2)

There are two types of berth for nuclear powered submarines in Scotland. These are:

CATEGORY X BERTHS - berths frequently used by nuclear powered submarines (normally their operational base). There are five such berths at the Clyde Submarine Base, Faslane and the Rosyth Royal Dockyard has at least two.

CATEGORY Z BERTHS - berths only occasionally visited by nuclear powered submarines, where they rest the crew, pick up supplies etc. There are 30 of these in Scotland. These are shown on the map overleaf.

The Royal Navy does not classify the United States Naval Base at the Holy Loch as a base for nuclear powered submarines, but ClydePubSafe is intended to encompass the submarine berths at this base.

In addition to planning for accidents involving nuclear powered submarines, ClydePubSafe is unique as it is intended to cover nuclear weapons accidents too, although specific measures for this type of emergency are not dealt with in any detail.

3. THE PRESSURISED WATER REACTOR

All British and American submarines use Pressurised Water Reactors (PWRs) in which water acts as both coolant and moderator. (See Figures 1 and 2 overleaf.)

In such a system water passes round the primary circuit, several times through the nuclear reactor and thence to a steam generator. The cooling water in the primary circuit has to be kept at a high pressure to prevent it boiling and turning to steam. This is achieved by including a pressuriser in the primary circuit.

Steam at the top of the pressuriser is used to compensate for changes in coolant volume, as the reactor inlet and outlet temperatures vary.

In the steam generator the heat energy is transferred from the water in the primary circuit to unpressurised water in the secondary circuit, which then becomes steam and passes through the secondary circuit to the main turbine.

Having driven the turbine the steam goes into a series of condensers, becoming water once again and returning in liquid form to the steam generator to continue the cycle.

PWR condensers use sea water as a heat sink and require a constant throughput, provided either by the forward motion of the submarine or, at low speeds, by the use of pumps.

The operation of a PWR requires considerable auxiliary power, mainly to operate the circulation pumps in the primary circuits and the electrical heater elements in the pressuriser.

4. TYPES OF ACCIDENT AND RISK ESTIMATES

The Royal Navy have claimed on many occasions that nuclear powered submarines are far safer than civil nuclear power stations.

However, due to the restricted amount of space in a submarine, shielding has been sacrificed to reduce weight and increase speed and manoeuvrability. Safety systems that are standard in civil nuclear plants have been omitted or have been reduced.

In a normal civil reactor, the final containment consists of extremely thick concrete walls which, of course, are unlikely to melt. The final containment in a submarine is simply the hull of the submarine and, being steel, it would melt at a relatively low temperature.

Submarine propulsion systems, because of their size, mobility and the hostile environment in which they must operate, are exposed to substantially greater risks than land-based nuclear power stations; potential accident situations are appreciably more numerous because of the possibilities of collision, fire, sinking, grounding, stranding, and sea effects etc. [3] (See Appendix 6)

In his book *Submarine versus Submarine*, R. Compton Hall states:

> *The reactor compartment containing the entire primary circuit is shielded by lead and polythene which generally accounts for between 20-30 per cent of the plant's weight ... a total coolant failure in any nuclear plant is disastrous and inevitably leads to a melt-down of the core. Western submariners are absolutely certain that their safety devices and back-up systems will never allow this to happen. The Russians said the same - until Chernobyl. They are notoriously relaxed about safety; serious accidents, human errors, action damage ... could cause havoc ...* [4]

ClydePubSafe initially described two possible types of reactor accident; ScotSpecSafe and RosPubSafe still set out these accident scenarios in detail, but as a result of revisions of ClydePubSafe, most of the detailed descriptions of these scenarios have been omitted.

The two accident scenarios referred to are the **Maximum Design Accident (MDA)**, where the reactor compartment remains intact and there is little chance of a radioactive release to the environment, and the **Primary Containment Failure Accident**, where the reactor compartment is breached and there could be a sudden, large release of radioactive materials to the environment.

The **Maximum Design Accident** would begin with a leak in the primary coolant system brought about for example by pipe failure. As a result of the loss of coolant water the fuel cladding could eventually melt, releasing radioactive fission products into the compartment containing the reactor and its associated systems, which is known as the 'primary containment'.

The **Primary Containment Failure Accident** would occur if the submarine's primary containment were to fail after an **MDA** and disperse the radioactive fission products throughout the submarine, and eventually into the atmosphere.

The **Maximum Design Accident**, according to the Royal Navy, has a probability of occurring once in every 10,000 years of reactor operation, and could result in a release of 1,000 curies of iodine 131 and 100,000 curies of 'other volatile and gaseous fission products' over a period of 24 hours.

The **Primary Containment Failure Accident**, according to the Royal Navy, has a probability of occurring once in every million years of reactor operation,and could result in a release of 100,000 curies of iodine 131 and 10,000,000 curies of 'other volatile and gaseous fission products' over a period of one hour.

The Royal Navy defines two emergency states, on which they base their response to any accident. These are:

Nuclear Reactor Accident Category 1

This is defined as an unexpected event involving a nuclear reactor plant which is likely to lead to a radiological hazard external to the reactor plant. **This state also covers the situation where information has not yet been obtained about the seriousness of the accident.** At this state organisations involved will come to a state of readiness.[5]

Nuclear Reactor Accident Category Two

This is defined as an unexpected event involving a nuclear reactor plant which has resulted in a radiological hazard external to the reactor plant. At this stage the plan of action for such an emergency would be brought into operation.[6]

The following statement explains how the Royal Navy decide when a reactor incident or accident becomes an event that local authorities should be informed of.

> *An emergency will be declared on the occurrence of any accident causing or likely to cause the release and spread of radioactive material in such a way* ***that there would be interference with the normal activities of the public.*** (my emphasis) [7]

The 'other volatile and gaseous fission products' mentioned in the public safety schemes include such hazardous radioactive materials as caesium 137 and strontium 90. The public safety schemes concentrate on trying to protect the public against the effects of exposure to iodine 131 by issuing potassium iodate tablets to all those felt to be at risk. The public safety schemes do not mention any specific remedies for exposure to other radioisotopes

The Royal Navy have never published any technical or engineering data to justify their selection of likely accident scenarios, their probability statistics (which are in any case extremely vague), or their release estimates.

They have analysed other possible accident scenarios in detail, but will not release details of them. They have decided to prepare plans for the Maximum Design Accident only.

An indication of the real risks may be gained from a series of articles in the *Journal of Naval Science*[8], written by and for the Royal Navy, which reveals that there were 712 incidents involving submarine nuclear reactors between 1964 and 1978 - an average of roughly one a week; between 1973 and 1978 there were 106 'reactor scrams' - a rough average of one every ten weeks (a 'reactor scram' involves the control rods being inserted fully into the reactor in order to shut it down. This can be caused by either reactor component malfunction, or a breakdown in an instrument that monitors plant operations, so many reactor scrams need not indicate an emergency).

The articles also state that the Royal Navy have a 'spurious scram' once every 3½ reactor operating years. These are described as reactor shut-downs 'which can only be attributed to an irresponsible malfunction of the Reactor Protection System', and are said to be 'mercifully rare'. By 1978, when the articles were written, the Royal Navy had roughly 150 reactor operating years' experience. This implies that they suffered roughly 43 spurious scrams between 1964 and 1978, an average of one every four months.

The potential risks of collision with other sea traffic are illustrated by this article which appeared in *Scotland on Sunday* on 26th November 1989:

> *The Navy has begun an investigation into a breach of communication rules that led to a submarine breaking shipping regulations and crossing the path of a tanker fully laden with liquid gas in the Firth of Forth.*

Oil tankers and ships carrying other hazardous cargoes use the Forth and the Clyde frequently.

A detailed list of all nuclear powered submarine accidents known to have occurred to date is contained in Appendix 6.

5. THE 550-METRE ZONE

Like all other Royal Navy public safety schemes, the Scottish schemes propose the immediate evacuation of all personnel from an area of 550 metres radius around the site of a submarine reactor accident. This immediate evacuation distance very rarely impinges on the civilian population, but in Scotland there are five berths where this distance would entail the evacuation of members of the general public. These are:

Brodick Bay - 10 people
Campbeltown - 9 people
Holy Loch - 228 people
Rothesay - 121 people
Breiwick (Shetland Islands) - 48 people

The first four berths mentioned above are covered by ClydePubSafe. The fifth is covered by ScotSpecSafe.

In ClydePubSafe, the Royal Navy states: 'All other berths in the Clyde Area except Faslane are chosen on the basis that there is only **minimal** civilian population within the 550 metre zone.' (my emphasis) It is apparent from the figures given above that 'minimal' has a rather broad interpretation in this context.

No pre-planning is set out in the public safety schemes to evacuate members of the general public living within 550 metres of a nuclear powered submarine berth. The onus for such evacuation is placed on the local authorities involved.

Two main measures would be taken to protect all those living within this zone (comments in quotes are taken from ClydePubSafe, but the advice in ScotSpecSafe is broadly similar):

1) Everyone in the area except essential personnel should be evacuated. 'It is unlikely that evacuation of members of the civilian population will become necessary.'

2) The distribution of potassium iodate tablets should be undertaken. 'The civilian population within a radius of 550 metres of the nuclear warship will be issued with potassium iodate tablets supplied to the Local Accident Committee by the Commodore Clyde and will be evacuated as advised by the local police.'

The following emergency action is to be taken by the Chief Executive of the area concerned:

Category 1 reactor accident (an incident which **could** lead to a release of radioactivity to the environment): 'Prepare to issue potassium iodate tablets. (Supplied by Commodore Clyde). Make preliminary arrangements to evacuate all persons within 550 metres of the nuclear powered warship.'

Category Two reactor accident (an incident which **has** resulted in a release of radioactivity to the environment): 'Issue potassium iodate tablets to the population within 550 metres of the warship at the time of the accident, if advised to do so by Commodore Clyde and if this has not already been done by the local health authority.'

NB - ClydePubSafe states that: 'under certain circumstances a Category 2 may be declared without a Category 1 Accident having been declared'.

Under the section of ClydePubSafe covering emergency action to be taken by the Chief Administrative Medical Officer of the Area Health Board no mention is made of the fact that tablets should be distributed immediately to all those living within 550 metres of an accident, or who should undertake this.

During a crisis it is highly unlikely that there would be time to draw up plans for evacuating the public from within 550 metres of a particular berth and distributing potassium iodate tablets. As potassium iodate is most effective if administered before or in the very early stages of exposure, there is an urgent need to draw up in advance a clear emergency plan. Also, at least those who live within these 550-metre zones, if not the general public living further afield, should be informed fully, in advance, of provisions for their care and protection in the event of an accident.

Few people who would be affected even know of the existence of these public safety schemes, let alone the cooperation that would be required of them. Copies of these schemes, which are unclassified, have disappeared or are not available at several public libraries where they should be available to the public.

Public information campaigns have been carried out in the past by civil and governmental nuclear establishments. One such campaign was carried out by the United Kingdom Atomic Energy establishment at Harwell. A copy of the leaflet they distributed to all local people within their immediate evacuation distance is reproduced in Appendix 3.

This leaflet appeared to go down very well with the general public and did not cause any great anxiety:

> *In the absence of any evidence of criticism from the public we can only assume that the operation caused no measurable anxiety.* [9]

6. REVISING THE 550-METRE ZONE

The 550-metre immediate evacuation zone itself is considered to be grossly inadequate by many experts. W. Jackson Davies Ph.D, an American biologist, has carried out numerous studies into the possible consequences of accidents involving naval nuclear reactors and nuclear weapons. These studies used calculations recommended by the Nuclear Regulatory Commission in the USA to establish the likely spread of radioactive materials after an accident involving a 100-megawatt naval nuclear reactor. Other experts consider Jackson Davies's studies to be conservative in their estimates, yet the results are still a major cause for concern.

One of the main recommendations made by Jackson Davies in all his studies is that evacuation needs to be extended to a minimum of 5 kilometres from the scene of an accident. (10)

The 'Clyde Area Public Safety Scheme' and many others provide support for this recommendation:

> *The sudden release of fission products to atmosphere directly from the primary containment ... could result in a health hazard at distances up to five kilometres downwind.* (11)

For some unknown reason, however, the same paragraph in the 'Scottish Special Safety Scheme' doubles this figure.

> *The sudden release of fission products to atmosphere directly from the primary containment failure accident or 'uncontained accident' could result in a health hazard at distances up to 10 km downwind.* (12)

The Royal Navy estimate the maximum radius within which an accident will present a hazard to be 10 kilometres:

> *The probability that any individual more than 10 km downwind could exceed any of the upper level ERLs [Emergency Reference Levels] is so remote that there is no requirement for any accident pre-planning outside that distance.* (13)

Roughly 35,000 people live within a 5-kilometre radius of all the berths in Scotland (excluding the berths at Rosyth). The maximum number of people living within one particular 30° 5-kilometre downwind sector is at Thurso Bay, where 9,822 people may be at risk.

Roughly 150,000 people live within a 10-kilometre radius of all the berths in Scotland (excluding the berths at Rosyth). The maximum number of people living within one particular 30° 10-kilometre downwind sector is at the Holy Loch, where 21,467 people may be at risk.

7. SHELTERING

The first emergency action taken by any local authority is likely to be an announcement advising people to take shelter. This announcement, released primarily through the media, will advise people that there has been an accident and that they are to remain indoors, keep all doors and windows closed, and eat only canned food.

However, this is purely a temporary measure. The US Environmental Protection Agency has pointed out that:

> *Generally, shelter provided by dwellings with windows and doors closed and ventilation turned off would provide good protection from inhalation of gases and vapors for a short period (i.e. one hour or less) but would be generally ineffective after about two hours due to natural ventilation of the shelter.* [14]

The Royal Navy have set a time limit of 36 hours during which decisions must be taken on how many people to evacuate and from where. Therefore, people may have to remain inside their homes for up to 36 hours after an accident before further action is taken.

No consideration is given to how people at work, shopping in town or camping on a hillside, for example, are to shelter from the radiation.

8. EVACUATION

The major reason for evacuating people is to try to limit the amount of radiation dose they receive, so it is obvious that this measure will be fully effective only if carried out before the radioactive cloud arrives, or immediately after. To achieve a result which even approaches this would require advance planning and an efficient emergency monitoring programme. Neither of these exist in Royal Navy public safety schemes.

In the event of a nuclear reactor accident the decision to evacuate an area rests with the civil police, in particular the 'Incident Commander'. The responsibility for feeding, clothing and rehousing refugees rests with the local authority.

To establish the basic principles involved in evacuation, police forces establish 'Force Permanent Operational Orders'. These are not site-specific and deal with many situations which may necessitate evacuation, such as fires, gas leaks, hostage/firearms incidents, bomb threats, and flooding or other natural phenomena.

The police force 'Incident Commander' would face a major dilemma when considering evacuation as a protective measure after a nuclear reactor accident. He or she would have to decide whether bringing people out into the open to evacuate them, when high levels of air and ground contamination may exist, would be safer than leaving them where they were. The Royal Navy would be consulted before any decisions on evacuation were taken.

People will not always follow what someone in authority has told them to do. Some may well seek additional information as well as reassurance from friends, relatives, family doctors, pressure groups, the emergency services or the media. Any messages sent out about evacuation need to be clear, simple, understandable, current and timely.

There may be problems after an accident with 'self evacuation': members of the general public fleeing from their homes after initial news reports of an accident. This will compound the problems for the emergency services.

Parents with children at school at the time of an accident require special consideration. They will all have an overwhelming desire to ensure their children are safe before considering protecting themselves. They need reassurance that their children are safe and that families will be reunited at Evacuation Reception Centres. Nowhere in any of the Royal Navy public safety schemes is consideration given to the problems of:

(1) handling the evacuation of children and parents separately
(2) evacuating the elderly, the infirm and the disabled
(3) feeding, clothing and housing evacuees
(4) deciding how much luggage evacuees may take with them
(5) evacuating everyone (is personal transport to be used or will transport be provided?)

The school meals service may have to be informed of the need to provide food. Local charity shops and clothes stores may need to be 'raided' to provide spare clothing. Social Services might need to be informed so that they may be on hand at Reception Centres to provide expert advice and counselling to evacuees. Local hospital supply depots may need to be contacted to provide soap, towels, blankets and bedding. Evacuation centres would need to be found and opened up. Buses and other forms of transport would need to be found to evacuate people who do not have any transport. Preparation for evacuation needs to be extensive, and should be undertaken in advance of any crisis.

The basics of a proper civilian emergency evacuation plan could be organised in advance of an accident happening, covering details such as Evacuation Reception Centres with enough facilities to carry out decontamination; liaison with all organisations that would become involved in an evacuation to ensure they are aware of their roles, and a public information campaign to ensure that, if evacuation is necessary, the public will at least have a minimal amount of knowledge as to what measures are likely to be taken to protect them.

Ideally such pre-planning should cover a 5-kilometre radius around every submarine berth in Scotland. However, as a start, proper protective measures should be implemented to cover everyone, military and civilian alike, living within a 550-metre radius of nuclear powered submarine berths.

If evacuation were carried out, evacuees would be required to go to a reception centre. At these centres there would be a need to provide personal monitoring in order to determine what radiation doses had been received, if any, to give reassurance, and evaluate consequent health implications. The priority would most probably be to detect any surface contamination on people's clothes, skin or hair.

Personal monitoring and decontamination can be a traumatic and stressful experience. Therefore, not only should monitors be fully experienced, but medical advice and counselling should be on hand.

Gymnasiums, sports centres or similar facilities would be ideal for use as reception centres as they have changing rooms, high-capacity showers and large halls for assembling evacuees. These would have to be outside the Royal Navy's 'no hazard distance' - a 10-kilometre radius from a nuclear powered submarine berth.

Personal radiation monitoring and subsequent decontamination of evacuees is not an easy task and is very time-consuming.

Personal monitoring of civilians was attempted during a nuclear weapons accident exercise in the United States. It was not as easy as first thought:

> *As an example of the time required for processing all personnel were withdrawn from the RCA [Radiation Contaminated Area] at 1800 hours on D-Day at which time approximately 60 people required processing through the Navy CCS [Contamination Control Station]. Processing was not completed until 2015 using a dual line. Processing time was approximately four minutes per person. To place this problem in perspective it should be noted that it was simulated that 815 residents were evacuated from the area on the basis of initial ARAC [Atmospheric Release Advisory Capable] plots.* (15)

To have monitored all these evacuees would have taken 54 hours and 20 minutes with just one processing line.

Monitoring all those within the most populous 5-kilometre 30° sector (the 9,822 people mentioned earlier at Thurso Bay) after evacuation would take 654 hours and 48 minutes with only one monitoring station available. It would take 28 monitoring stations 24 hours to complete this task.

Appendix 1 of this report outlines the time it would take to carry out a full personal radiation monitoring programme of all evacuees within the most populous 30° 5-kilometre sector for each berth in Scotland with only one monitoring station available. It further outlines how many stations would be required to monitor those same people within 24 hours.

9. DISTRIBUTION OF POTASSIUM IODATE TABLETS

The logistics of distributing potassium iodate tablets do not seem to have been considered in detail.

The public safety schemes plan to distribute potassium iodate tablets automatically to all military personnel within 550 metres of a submarine accident. The plans for distributing potassium iodate tablets to the public within this area are minimal and probably unworkable.

The tablets are intended for issue to prevent the irradiation of the human thyroid gland through either inhalation or ingestion of any form of radioactive iodine. They work by saturating the thyroid gland with a stable (non-radioactive) form of iodine, which prevents the gland from taking in any more iodine from the environment. However, these tablets cannot prevent external irradiation of the thyroid, nor do they give protection from the effects of other radioisotopes.

The thyroid gland is an important organ, it affects the control of emotional development, hair growth, cellular metabolism, bone development, sex organ development and kidney function.

The tablets themselves can have adverse health effects, for example, iodine sensitivities, possible effects on the developing thyroid in the foetus, and effects on those with potentially overactive thyroids.[16] These tablets can only be distributed to members of the public on the authority of a district medical officer, and usually only when the benefits far outweigh the risks.

Stable iodine can occasionally induce nausea and vomiting.[17] It would be desirable, therefore, to have someone available who could establish that people were not suffering from the effects of severe radiation sickness, and who could reassure them.

To be effective the tablets have to be administered immediately before, or at the time of, exposure; they should be distributed to all those thought to be at risk within, at most, one hour of an accident:

It has been shown experimentally that a dose of 100mg of potassium iodide [a form of iodine sometimes used] is virtually 100% effective if taken immediately before or at the time of exposure to radioiodine, 75% effective if taken 1.5h afterwards, and 50% effective if taken 5.5h later. (18)

Using W. Jackson Davies's recommended evacuation distance of 5 kilometres, and assuming that immediate evacuation is impossible (see Chapter 8 'Evacuation') ways would have to be found to alleviate at least some of the effects of radiation on everyone within that area. As a temporary measure, sheltering and distribution of potassium iodate tablets might be adequate. Like evacuation, however, this would be quite an undertaking.

Appendix 2 shows the maximum population in any one 30° sector out to 5 kilometres at every berth in Scotland (except Rosyth). It is assumed that there are on average three people living in each household; the number of distributors in the calculations are, therefore, per household, not per person. The times given assume that it would take distributors 5 minutes to move between houses, knock on the door, wait for an answer, explain the situation, and give out the proper dosage for that household along with an explanatory leaflet. Time to answer any special queries is not included. On these assumptions the numbers of distributors required quoted are the absolute minimum. The public safety schemes also assume that the police would take on this task, but they do not address the question of transport or availability of distributors, both of which may be needed for other emergency tasks.

Even if sufficient distributors can be found, equipped and deployed, there would be additional problems: the distributors would be the first figures of authority to face members of the public. Hampered by the need to wear face masks, they will be confronted by people in various emotional states. Even the calmest of these would probably need reassurance and require advice. Among the questions that could be put to distributors are:

- 'I'm allergic to iodine. What should I do?'
- 'My child has been vomiting. What happens if it cannot keep them down?'
- 'I suffer from lupus and shouldn't take these tablets. What should I do?
- 'I already take thyroid tablets. Should I stop?'
- 'I'm pregnant and shouldn't take anything. Is it alright to take these?'
- 'We've been drinking. Can these be mixed with alcohol?'

Unless distributors are members of the medical profession, they are unlikely to be able to answer such questions properly, or with any degree of authority. This is backed up by a letter from Oxfordshire Area Health Authority detailing why they are responsible for distributing iodate tablets in the event of an emergency at Harwell:

> *We have considered other ways of distributing iodate once the emergency has happened, for example by the police or Harwell staff. However, I am advised that neither organisation would be as well placed to deploy staff who could answer the local residents questions about their health, the risks in the emergency and about the iodate tablets.* [19]

A leaflet intended to be distributed with the tablets explains very little about them, their purpose, possible side-effects etc. In a cursory manner the leaflet sets out the dosage, states that the tablets are perfectly safe, and that people should remain indoors until further notice. Having read it, people are meant to pin it on their door to indicate that they have been visited. (See Appendix 4)

10. GAMMA SHINE

'Gamma shine' is the common name given to the intense gamma radiation (similar in some ways to X-rays) emitted from a submarine reactor in even a relatively minor accident. Gamma radiation would be emitted in any accident involving the rupture or melting of the cladding around the fuel elements inside a submarine's nuclear reactor. There may be no visible external damage to any part of the submarine, and there may be no release of radioactive fission products released into the environment. The gamma radiation would be of such high energy that it would penetrate the submarine hull and still be of sufficient intensity 'to pose a hazard to the health of those within the immediate vicinity of the submarine ...' [20]

The area stated to be at risk from this gamma shine varies from public safety scheme to public safety scheme. In the 'Clyde Area Public Safety Scheme' (ClydePubSafe) and the 'Scottish Special Safety Scheme' (ScotSpecSafe), gamma shine is said to present a danger up to 250 metres from the submarine hull. The 'Southampton Special Safety Scheme' (SotonSafe) warns that: '... excessive radiation doses could be acquired by personnel who do not evacuate immediately from points within the close vicinity of the warship'.

Gamma radiation can destroy cells and upset normal body functions. High doses can cause loss of hair, aplastic anaemia, and may affect the bone marrow, spleen, lymph nodes, and the manufacture of red and white blood cells.

The gamma shine phenomenon is especially worrying at bases like Faslane and the Holy Loch, where three or four nuclear powered submarines are berthed close together at any one time. No consideration seems to have been given to ensuring that sufficient personnel stay on board every other submarine in the base to keep the reactors operating normally, and ensure that another accident does not occur.

Such considerations will probably entail servicemen risking their health or their lives, as the Royal Navy admits:

> *If a reactor accident occurs it will, in the early stages, be extremely hazardous for even properly protected personnel to approach close enough to the submarine to observe the course of events in detail.* [21]

11. REGISTRATION AND COMPENSATION

To provide evidence for possible claims for compensation many years after an accident, members of the general public would be required to register the fact that they were in a controlled area at the time of the accident. These forms are not automatically released after any accident, it is a matter of discretion on the part of the MoD. People who feel they may have been affected by the radioactivity released have one month to collect forms from post offices in the affected areas or from the Ministry of Defence. These forms are valid for 30 years. How do people get the forms if they have been advised to stay at home or if they have been moved from the affected area? Is 30 years long enough, should they not be valid for the lifetime of the registered person?

There is no legislation which covers compensation for nuclear injury or damage after an accident involving a nuclear vessel. Neither will any insurance company cover you for that type of event. However, in all the public safety schemes the MoD assure us that

> *claims under the principles for nuclear injury or damage (including the sole and absolute liability of the operator) established by the Nuclear Installations Act 1965 ... will ... be dealt with according to the same principles.*

In the event of an accident involving the US Navy, claims will be dealt with under special arrangements (which are not specified) in consultation with the US authorities.

12. SECTION 1 REFERENCES

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(2) 'Scottish Special Safety Scheme (ScotSpecSafe)', Royal Navy, August 1988

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(4) R. Compton. Hall, *Submarine versus Submarine*, David and Charles Military Book, 1988

(5) 'Clyde Area Public Safety Scheme (ClydePubSafe)', Royal Navy, 1986

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(8) Professor J. Edwards and Commander K.F. Tucker, 'Royal Navy Requirements and Achievements in Nuclear Training', in: *Journal Of Naval Science*, Greenwich Naval College, Vol. 4, No. 3, 1978 pp. 163-4

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(11) 'Clyde Area Public Safety Scheme (ClydePubSafe)', Royal Navy, 1986

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SECTION 2

BERTHS FOR NUCLEAR POWERED SUBMARINES IN SCOTLAND

- A CRITIQUE OF PUBLIC SAFETY SCHEMES

INTERIM REPORT

13. INDIVIDUAL BERTHS

This chapter highlights some of the problems with individual berths which are not discussed in detail in the Royal Navy's emergency plans.

The general problems which apply to all the berths have been outlined in Section 1 of this interim report. In addition, a number of the berths in Scotland have problems which make them worthy of special attention, and these are dealt with below. Where possible, the military purpose of particular berths is also noted.

THE SHETLAND ISLANDS

Military Purpose

Naval Port HQ. Regularly visited by NATO vessels, particularly diesel submarines tasked to 'barrier' patrols in the Iceland-UK gap, during NATO maritime exercises.[1]

There are 5 submarine berths, and roughly 10,000 people at risk from a nuclear reactor accident, on the Shetland Islands. Three of these berths are clustered around Lerwick, the main town, with a population of over 7,000. 48 people live within a 500-metre radius of the berth at Breiwick. At all the other berths on Shetland there is no resident population within a 500-metre radius. All these berths are covered by the 'Scottish Special Safety Scheme' (ScotSpecSafe).

For the 48 people at Breiwick, there are no clear guidelines in ScotSpecSafe that potassium iodate tablet distribution should be automatic as soon as an accident occurs; also, there are apparently no plans for the immediate evacuation of these people.

There are 6 hospitals with 229 beds within 5 kilometres of the berths clustered around Lerwick.

The evacuation of hospital patients and the sick, handicapped and infirm within the community poses particular problems and difficulties.

Berth 3 in South Lerwick Harbour is cleared for use by nuclear powered surface ships, including large US navy aircraft carriers with up to 8 PWRs (800 megawatts), like the US aircraft carrier USS *Enterprise*. The Nimitz class of US aircraft carriers carries 2 PWRs, and there are also nuclear powered US cruisers. No Royal Navy public safety scheme would be able to cope with an accident involving these types of vessels.

It is normal practice in England and Wales for the Royal Navy to co-deploy an emergency radiological monitoring team, plus a mobile monitoring headquarters, for the duration of a nuclear powered submarine's stay at any berth where there is no permanent monitoring capability. The Shetland Islands will have no emergency radiological monitoring capability if a submarine visit is for a period of 24 hours or less. If an accident were to happen during one of these short visits, it would take at least a further 24 hours to get the necessary specialised monitoring vehicles onto the Islands. Until these vehicles arrive, there can be no effective radiation monitoring programme. If air support is available Royal Naval health physics personnel and other specialist advisers could be flown into the islands within four hours. Without any form of air support, those members of the Local Accident Committee already living on the islands would have to cope on their own for the first 24 hours, not knowing how bad the levels of radiation were, or how far it had spread. Due to the distance involved there should be a full Royal Navy radiological monitoring capability present on the Shetland Islands no matter how brief the nuclear vessel's visit.

As mentioned previously, three of the berths in the Shetland Islands are clustered around Lerwick. These berths are also all within a 1-kilometre radius of the route used by the Aberdeen to Lerwick roll-on roll-off ferry. If an accident were to occur at one of these berths there could be serious problems in using the ferry to transport equipment or people in or out of the Shetland Islands.

THE UNITED STATES NAVAL BASE, HOLY LOCH

Military purpose

This base is the homeport for 8 US nuclear powered ballistic missile submarines, each armed with 16 Poseidon missiles. Each missile can carry up to 10 warheads. Three or four of these submarines may be berthed at the Holy Loch at any one time. The submarine support ship can store a further 20 Poseidon missiles. This means that there can be as many as 70 Poseidon missiles, 4 nuclear reactors and a large quantity of conventional ammunition all within close proximity of each other at certain times.

This is a unique situation. At the nearby Clyde Submarine Base (Faslane and Coulport) volatile missile fuel, nuclear warheads, nuclear reactors and conventional munitions are all kept well apart for the majority of the time. The close proximity of all these accident potentials to one another could turn a relatively minor accident into an absolute catastrophe.

The Holy Loch has not been cleared by the Royal Navy as an area suitable for berthing nuclear powered submarines. 228 people live within 500 metres of the Holy Loch. 12,500 people live within a 5-kilometre radius, and within a 10-kilometre radius there are almost 50,000 people.

Duncan Campbell noted in his book, *The Unsinkable Aircraft Carrier*, that a base similar to the Holy Loch would not be allowed in the United States.

> *One good statistic to remember is that the blast safety zone required around a tender with four Poseidon submarines alongside is in excess of 9,000 feet. That is about a 3 mile diameter clear zone around it ... one looks for that, plus accommodating a dry dock which has its [own] blast safety zone ...* (2)

At the Holy Loch, emergency plans to cope with an accident involving the submarines or their weapons systems are virtually non-existent. Even though nuclear powered submarines are constantly present at the base, there is no 24-hour Royal Navy radiological monitoring capability. There is, however, an unstaffed office nearby that could be activated in the event of an accident. The US Navy have a small radiation monitoring capability, primarily established to cope with nuclear weapons accidents. In ClydePubSafe there is no mention of what assistance could or would be provided by the US Navy in the event of a nuclear reactor accident on board one of their submarines.

Royal Navy radiation monitoring vehicles would take about 90 minutes to reach the Holy Loch and start monitoring for radioactive contamination. Without air support, the Local Accident Committee could take up to 2 hours to convene. During this period there would be no official body available to coordinate the immediate emergency response effort. Therefore, initial response to an accident would be left up to individuals, their initiative and what has been outlined in advance within the emergency plan.

Because of this delay, the emergency plans should set out, in far greater detail than at present, what should be done to protect the public in the first few hours after an accident. In particular, far clearer guidelines should be laid out on what is to happen to the 228 members of the general public who live within a 500-metre radius of the Holy Loch.

At present, all military personnel within a 550-metre radius of a nuclear reactor accident when it occurs would be evacuated and given potassium iodate tablets. This would happen automatically. As mentioned previously there are 228 people living within 500 metres of the base, but the instructions given for their immediate protection are confusing and inadequate.

Evacuation of these people is 'unlikely to become necessary', according to the Royal Navy. Distribution of potassium iodate tablets will either be carried out by unspecified personnel instructed to do so by the Local Accident Committee, who would in turn get their tablets from the Commodore Clyde, or by unspecified personnel from the local health authority using their available stock. In both cases, distribution of tablets to the public would not start until the Commodore Clyde had called for it.

It should be established that one body, with readily available supplies of tablets, will carry out distribution of these tablets on being notified of an accident. A similar procedure should be outlined for the evacuation of those same people. This would provide the same level of protection to everyone, be they military or civilian.

A serious question arises about notification of an accident. Who will a United States Navy Commander notify first, his own superiors or the Commodore Clyde?

At present the emergency plans for the Holy Loch are far from adequate. A comprehensive emergency plan should be drawn up, separate from any other emergency plan. Many questions remain unanswered, many problems still have to be overcome. Until some of the points raised above are answered there can be little hope of there being an adequate response to a nuclear reactor accident at the Holy Loch.

CAMPBELTOWN

Military purpose

Near the town there is a NATO petroleum, oil and lubricants depot, used by a wide variety of NATO ships, diesel submarines, Royal Fleet Auxiliary vessels and other military tankers, particularly during major NATO exercises.(3)

There are four berths near Campbeltown, which has a population of around 8,000 people, although this increases considerably during the summer months. Nine people live within 500 metres of one of the berths. Campbeltown is also cleared for use by ballistic missile submarines. There are two hospitals with a total of 77 beds available within 3 kilometres of the berths. It could take 3 to 4 hours for Royal Navy monitoring teams to arrive.

DOUGLAS PIER, LOCH GOIL

Military purpose

Admiralty Marine Technology Establishment outstation used for trials of torpedoes and underwater test vehicles on the noise range in Loch Goil, which is 'primarily for the routine measurement of noise emitted by naval vessels and submarines, but ... also used for other acoustic purposes.' Loch Goil has been used for sonar research since 1942.(4)

The nearest major population centre is Lochgoilhead and Carrick, with a population of 500, just over 4 kilometres away.

GLEN MALLAN, LOCH LONG

Military purpose

NATO jetty built in the 1970s to serve the NATO Arms Depot at Glen Douglas, to which it is connected by road.(5)

SKYE

Military purpose

At Kyle of Lochalsh, Wester Ross, there is the British Underwater Trials and Evaluation Centre (BUTEC), the main trials range for torpedoes and other undersea warfare equipment in Britain. The range area covers about 10 square miles of the inner Sound of Raasay, while the danger area extends to about 130 square miles. Submarines account for about 95% of the firings at BUTEC.(6)

There are 4 submarine berths scattered around the Isle of Skye. The first is 3.5 kilometres from the town of Portree, which has a population of 2,000. The second is in Broadford Bay, 5 kilometres from the town of Broadford, which has a population of 900. The third is between Raasay and Applecross and the fourth is at the mouth of Loch Torridon.

The population on the island can increase considerably during the summer. All the berths around Skye are connected with BUTEC. However, given the large area of water within which submarines operate, the entire operations area should be dealt with in one integrated emergency plan, rather than the present, minimal four-berth plan.

LOCH EWE

Military purpose

Aultbea is a NATO petroleum, oil and lubricants depot. The depot was built in 1966 to refuel Royal Fleet Auxiliary and other military tankers and warships, mainly during NATO naval exercises off the north of Scotland. Aultbea was built as a wartime facility; the funds used in its construction are solely for wartime operational facilities. Heavy fuel oil is stored in underground tanks in a 200-acre area behind the pier, with stocks being removed every few months to refineries in Holland and Spain for recycling. In 1981, due to future use of Aultbea by combined fuel and explosives supply ships, the MoD announced it wanted to ban all construction or new development within 900 metres of the pier and to have the right of veto over any developments within 2.3 kilometres (encompassing the whole of Aultbea village), due to an enlarged safety zone, because of the increased danger of an explosion. The new vessels are expected to visit Aultbea about 9 times a year.[7]

There are 2 berths in the loch, with 1,100 people living within a 9-kilometre radius of them. This population can treble during the summer months.

THURSO BAY

The town of Thurso, with a population of 9,000, is within 2 kilometres of the berth. Without air transport the Area Safety Panel could take 5 hours to assemble, during which time only the local members of the panel will be available to deal with the accident. Royal Navy monitoring teams could take up to 10 hours to arrive by road, although teams could be flown in within 2 hours.

ROTHESAY AND LOCH STRIVEN

Military purpose

A large, square area of sea-bed off Brackley Point is used for naval trials, with an undersea cable link to the east shore of the loch at Brackley Point. This is believed to be another Admiralty Marine Technology Establishment noise range. There is also a NATO petroleum, oil and lubricants depot built 1960-63 at a cost of £3 million, with NATO infrastructure programme funds. Used for refuelling of a wide range of NATO surface ships and diesel powered subsmarines. The oil storage tanks cover around 100 acres.(8)

There are 2 berths within a 2-kilometre radius of Rothesay and within 1 kilometre of Port Bannatyne. The third berth is at the entrance to Loch Striven.The population of Rothesay is approximately 6,300 and at Port Bannatyne 1,400. These figures can be increased six-fold during the summer months. There are 121 people living within 500 metres of the 2 berths at Rothesay.

INVERARAY AND LOCH FYNE

Military purpose

Admiralty Marine Technology Establishment (AMTE) underwater noise range 'primarily for routine measurement of noise emitted by naval vessels and submarines, but ... also used for other acoustic purposes'. On the south shore of Loch Fyne, near St Margarets, is a shore facility which is believed to be the control centre for the passive sonar arrays under the loch. The admiralty mooring buoys further down Loch Fyne, south of Ardrishaig, may be connected with the AMTE range, or could be earmarked as a wartime dispersal mooring for the US Navy SSBN depot ship from the Holy Loch (currently the AS 33 *Simon Lake.*)(9)

There are two berths here. One is in Loch Shira, Inveraray, the other being to the south in Loch Fyne. There are two towns here, Inveraray with a population of 1,100 and Strachur with a population of 650. According to ClydePubSafe there are less than 20 people living within 800 metres of the three berths (even though there are only two berths mentioned). 134 members of the general public live within 1 kilometre of the berth at Inveraray. It should also be remembered that during the summer the population in the area can increase greatly.

TARBERT

No known military purpose

Tarbert has a population of around 1,300 people. This again increases considerably during the summer months. Monitoring teams could be deployed within 2 to 3 hours.

ISLE OF ARRAN

No known military purpose.

There are two berths here, one in Brodick Bay and one in Lamlash Bay. The towns of Brodick and Lamlash have a total resident population of around 2,600 people, which can quadruple during the summer. Monitoring teams could be deployed within 2 to 3 hours. There are 10 people living within 500 metres of Brodick Bay. The berth at Brodick Bay is very near the Brodick to Ardrossan car and passenger ferry, the main route onto the island.

ROSYTH

Military purpose

First operational in 1916, when it played a major part in the repair of warships damaged at the Battle of Jutland. Between the wars it was placed in care and maintenance, only to be re-opened in 1938. In 1963, the dockyard was chosen as the first refitting base for nuclear submarines, the first of which arrived in 1970. There are two major facilities here - the naval base (HMS Cochrane) and the dockyard itself. Dockyard managers are contracted by the Ministry of Defence to carry out refuelling and refitting of nuclear powered submarines.

All comments on the emergency plans for Rosyth have been taken from the interim issue of the newly revised plan. The comments are therefore drawn from an incomplete plan that may be changed before it is finally issued.

ROSYTH PUBLIC SAFETY SCHEME - INTERIM ISSUE

1. This interim issue of RosPubSafe is to be used for future exercises and in the unlikely event of a real accident.
2. This version will be fully authorised after proving in the next exercise, and after MOD consideration of Part 1 Section 1.
3. The fully authorised version will then be produced in a properly bound form suitable for wider public distribution. Pending this, copies of the existing plan now in public libraries should not be replaced by this interim issue.
4. Any observations on the distribution list and number of copies supplied would be welcome. Those local authorities wishing to make a wider distribution in libraries of the final bound version are invited to state their requirements.

RJ Killick
CSO(N) for VICE ADMIRAL [10]

Dockyards and refitting yards are entirely different from normal submarine berths. Far more can go wrong and, as can be seen from Appendix 6, the majority of known accidents involving Royal Navy submarines have occurred in dockyards and refitting yards.

Vessels in dockyards are probably at their most vulnerable to accidental damage, especially from the risk of fire, with large numbers of workmen using welding equipment and blowlamps etc.[11]

Most of the criticisms of Royal Navy public safety schemes at other berths apply equally to Rosyth. In all fairness, the Rosyth Scheme does give some consideration to the evacuation of members of the general public outside the yard. It also mentions possible accident scenarios involving the refuelling operations at the dockyard, but only very briefly:

The most severe accidents are as follows:

a. Fuel Handling. Severe damage to a spent fuel container could result in exposure to one or more fuel modules. There would be no significant airborne contamination.
b. Waste Operations. The worst accident would be a major and sustained fire, which would cause an airborne release of the total Cobalt 60 inventory. However, the quantity of combustible material in this area is small. [12]

Any further discussion on this matter is dismissed as being irrelevant because the Royal Navy feel that:

> *The consequences of an accident during fuel handling or waste management operations are most unlikely to result in a hazard to the public, although if appropriate the arrangements described in this Public Safety Scheme will be invoked.* [13]

When refuelling is being carried out, the submarine is ripped open, and the entire reactor compartment is exposed to the air. Primary containment no longer exists. Because of the fact that weapons-grade uranium is used for the fuel in these reactors there is a danger of a criticality accident. This occurs when too much weapons-grade uranium comes together, forming a critical mass, which emits a large burst of radiation and heat and releasing radioactivity to the atmosphere.

This type of accident was one of the few that worried the United States when they were first refuelling their nuclear powered submarines.

> *During refuelling the yard had to guard against two types of nuclear accidents. The first was an inadvertent criticality of the reactor, which could result from improper manipulation of the fuel elements or control rods. There would be no explosion like that from a nuclear weapon but rather a burst of radiation and a sharp rise in temperature. Part of the fuel could melt and release fission products which could spread downwind from the submarine ... The second type of accident was the possible exposure of personnel to radiation during the removal of the depleted fuel from the pressure vessel.* [14]

14. SECTION 2 REFERENCES

(1) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 55

(2) Duncan Campbell, *The Unsinkable Aircraft Carrier*, 2nd edn., Paladin, 1986, p. 222

(3) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 123

(4) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 124

(5) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 134

(6) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 78

(7) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 61

(8) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 143

(9) Malcolm Spaven, *Fortress Scotland*, Pluto Press, 1983, p. 143

(10) 'The Rosyth Public Safety Scheme (RosPubSafe)', Royal Navy, August 1989

(11) M. MacLean, 'Naval Accidental Losses - A 25 year history', in: *Navy International* February 1989, p. 100

(12) 'The Rosyth Public Safety Scheme (RosPubSafe)', Royal Navy, August 1989

(13) 'The Rosyth Public Safety Scheme (RosPubSafe)', Royal Navy, August 1989

(14) Richard G. Hewlet and Francis Duncan, *Nuclear Navy, 1946-62*, University of Chicago Press, 1974

15. CONCLUSION

There are 30 berths for nuclear powered submarines in Scotland and many hundreds of miles of coastline where nuclear powered submarines are constantly present.

The Royal Navy's accident record is far from faultless and yet their accident probability statistics have remained unchanged since they were first devised. The Royal Navy's estimates of accident probability cannot be taken seriously.

The Royal Navy further estimate that initially radioactivity will spread no further than 550 metres from a submarine accident. No justification is offered for these figures. Most experts consider that this distance should be revised to 5 kilometres. Even within their 'immediate evacuation distance' of 550 metres, very little or no consideration is given to evacuating and caring for members of the general public.

No consideration is given to the possible need for large-scale evacuation of members of the general public, even though nuclear powered submarines regularly berth in areas where large numbers of people live.

The distribution of potassium iodate tablets is given only cursory attention. The question of how tablets are to be distributed to the public if this becomes necessary is not addressed.

Those wishing to claim compensation due to the effects of an accident, either on their property or their health, must collect a registration form from their local post office. How people are to do this, when they may have received instructions to remain indoors or may have been evacuated is not explained.

These forms are only valid for 30 years. Malignant cancers could appear many years after an accident. The form should be valid for the lifetime of the recipient.

Compensation from the United States government is apparently dealt with under 'special arrangements', but these arrangements are not explained.

This interim report draws attention to just some of the inadequacies of the Royal Navy's public safety schemes.

In general, their faults could be said to arise from a lack of imagination in foreseeing the obvious problems in implementing these public safety schemes. The public safety schemes have never been tested adequately, especially in terms of involving members of the public.

If this and future governments continue to maintain that the UK must have a fleet of nuclear powered submarines for the nation's defence, then the public are entitled to ask what protection will be afforded to them if there is a serious accident and what risks they are being asked to live with in the name of the 'deterrent' and the 'defence of the realm'.

APPENDICES

BERTHS FOR NUCLEAR POWERED SUBMARINES IN SCOTLAND

- A CRITIQUE OF PUBLIC SAFETY SCHEMES

INTERIM REPORT

APPENDIX 1

PERSONAL MONITORING AND DECONTAMINATION AFTER EVACUATION OUT TO 5 KM

Berth	Maximum Population	Time required with one monitoring station	Number of stations needed to complete the task in 24 hours or less
Faslane	1561	104 hrs 4 mins	5
Coulport	1290	86 hrs	4
Glen Mallan	208	13 hrs 52 mins	1
Holy Loch	6905	460 hrs 20 mins	20
Loch Goil	202	13 hrs 28 mins	1
Campbeltown *(NATO Jetty)*	3128	208 hrs 32 mins	9
Campbeltown *(Anchor Berth)*	2020	134 hrs 40 mins	6
Rothesay	4192	279 hrs 28 mins	12
Loch Striven	40	2 hrs 40 mins	1
Inveraray	198	13 hrs 12 mins	1
Loch Fyne *(Rosebank Buoy)*	259	17 hrs 16 mins	1
Brodick Bay	294	19 hrs 36 mins	1
Lamlash	299	19 hrs 56 mins	1
Tarbert	1277	85 hrs 8 mins	4
Loch Ewe *(NATO Pier)*	138	9 hrs 12 mins	1
Loch Ewe *('A' Buoy)*	129	8 hrs 36 mins	1
Portree	945	63 hrs	3
Raasay 'A' *(Broadford Bay)*	325	21 hrs 40 mins	1
Raasay 'B'	0	—	—
Raasay 'C'	5	20 mins	1
Thurso Bay	9822	654 hrs 48 mins	28
Lerwick Harbour	2722	181 hrs 28 mins	8
Breiwick	2199	146 hrs 36 mins	7
South of Lerwick Harbour	2676	178 hrs 24 mins	8
North Bressay	2528	168 hrs 32 mins	7
Dalesvoe	1171	78 hrs 4 mins	4

APPENDIX 2

POTASSIUM IODATE TABLET DISTRIBUTION OUT TO 5 KM

Berth	Maximum Population	Number of households	Number of personnel required to complete distribution within one hour	Time required for ten distributors to complete the task
Faslane	1561	520	38	3 hrs 43 mins
Coulport	1290	430	31	3 hrs 4 mins
Glen Mallan	208	69	6	30 mins
Holy Loch	6905	2302	164	16 hrs 27 mins
Loch Goil	202	67	6	29 mins
Campbeltown *(NATO Jetty)*	3128	1043	74	7 hrs 27 mins
Campbeltown *(Anchor Berth)*	2020	673	48	4 hrs 48 mins
Rothesay	4192	1397	100	9 hrs 59 mins
Loch Striven	40	13	1	6 mins
Inveraray	198	66	5	28 mins
Loch Fyne *(Rosebank Buoy)*	259	86	7	37 mins
Brodick Bay	294	98	7	42 mins
Lamlash	299	100	8	43 mins
Tarbert	1277	426	31	3 hrs 3 mins
Loch Ewe *(NATO Pier)*	138	46	4	20 mins
Loch Ewe *('A' Buoy)*	129	43	3	18 mins
Portree	945	315	22	2 hrs 15 mins
Raasay 'A' *(Broadford Bay)*	325	108	8	46 mins
Raasay 'B'	0	0	—	—
Raasay 'C'	5	2	1	—
Thurso Bay	9822	3274	234	23 hrs 23 mins
Lerwick Harbour	2722	907	65	6 hrs 29 mins
Breiwick	2199			
South of Lerwick Harbour	2676	892	64	6 hrs 23 mins
North Bressay	2528	843	61	6 hrs 2 mins
Dalesvoe	1171	390	28	2 hrs 47 mins

APPENDIX 3

ATOMIC ENERGY AUTHORITY HARWELL EMERGENCY INFORMATION LEAFLET

This information leaflet is designed to inform those living near to the Harwell Laboratory what would happen in an emergency. By the word 'emergency' we mean an accident involving the release of radioactive or chemically toxic material, such that it presented a health hazard to those living nearby.

It cannot be emphasised too strongly that the chances of such an accident occurring are very slight indeed. The design, construction and operation of the research reactors and other major plants are scrutinised by independent Advisory Safety Committees as well as by the UKAEA's Safety and Reliability Directorate at Culceth and the Health and Safety Executive. Working practices are carefully regulated and all experiments are carried out under very strict supervision. As a result there have been no serious accidents at Harwell in over forty years of operation.

Nevertheless, every large industrial plant needs emergency plans of some sort, and it is obviously sensible for the Laboratory to have emergency arrangements, to ensure that the necessary organisation is there if it is ever needed.

Plans for dealing with emergencies have been in existence since the earliest days of the Laboratory in the 1940s, although only a summary version of these arrangements has been available to the public. Now, in response to greater public interest in matters of safety, the Harwell Laboratory Emergency Handbook has been published (January 1987) and you can consult this in your local library.

Routine emergency exercises

Harwell Laboratory uses loud sirens (klaxons) as a warning device in the event of an emergency. The klaxons are tested on the first working Tuesday of January, April, July and October at 10am or 2pm. The test consists of a single continuous note (the 'all clear'), followed by a repeated short note (the emergency warning), followed by a single continuous note again.

Klaxon notes:

Emergency - repeated short note
All clear - single continuous note

The Laboratory stages a major emergency exercise each year. This ensures that Laboratory staff know how to deal properly and safely with any emergency that may arise. These exercises may involve the sounding of klaxons. The dates of these emergency exercises are published in advance in the Harwell bulletin (which is available from the Laboratory's Public Relations Department) but local residents receive a letter about them beforehand.

Emergencies on site

Staff on site would be alerted to an emergency by the sounding of klaxons. However, you do not have to rely on hearing these to know that there is an emergency at the Laboratory. The Harwell Constabulary will tour the estates surrounding the Laboratory, broadcasting a message through a loud hailer and the Thames Valley Police will contact and inform anyone else living within the affected area that there is an emergency at Harwell.

Once alerted to an emergency (either by klaxons or by the police), you are advised to follow this course of action:

Go indoors.
Close all external doors and windows and switch off any fans. This will limit the amount of any contamination entering your home.
Try to keep pets indoors with you, but if they are not around, don't look for them. Stay indoors and wait for them to turn up, then let them in and keep them inside.
Please do NOT telephone the laboratory for information, as staff there will be very busy.
Tune your radio to one of the following stations, as any special information about the situation will be broadcast on them:

Radio Oxford
MW 1485 kHz (202m)
VHF/FM 95.2 MHz

Radio 210
MW 1431 kHz (210m)
VHF/FM 97/102.9 MHz

GW Radio
MW 1161//936 kHz (258/320m)
VHF/FM 96.3/96.4/97.4 MHz

If you cannot find any of these stations, don't worry; information will be provided on other BBC and commercial radio and TV stations as well.

A Public Information Centre will be set up to deal with any specific queries. The telephone numbers will be broadcast on local radio and television stations (see above paragraph for wavelengths).

What if ...?

If you are working outside, please either make your way home if it is not too far away, or take shelter in a nearby house, and follow the above advice. All farm animals should be left where they are. You can take special action about their welfare later. (See also "Stock feeding").

If you are alerted during school hours, please do **NOT** rush to fetch your children from school. The police will make arrangements for the collection of children from any local schools affected by the emergency. Children will be re-united with their families as soon as possible; until then they will be safe in the care of their teachers at the Rest Centre (see also "Evacuation").

If the emergency turns out to be a false alarm, the 'All Clear' (single continuous note) will be sounded as soon as possible, and steps will be taken to inform all local residents.

Evacuation

It should be emphasised that no action to evacuate should be taken by householders until advised by the police. If evacuation is necessary, it will probably be on a very small scale indeed. If it is necessary for your safety, you will be contacted by the Thames Valley Police. A Check-List of things you might like to take with you is provided at the end of this information leaflet and repeated on the Information Cards which accompany this leaflet. You would normally be asked to use your own transport, but of course transport would be provided by Local Authorities for anyone who needed it. You can take household pets with you if you wish.

If you do have to leave, remember to make your house safe before you go. Put out the fire, for instance, and switch off electric fires and cookers. Lock it up securely. Whilst you are away your property will, as far as possible, be under the protection of the Thames Valley Police. Access to the area will be restricted, so please check you have everything you need before you leave.

The local authority will set up a Rest Centre at the Civic Centre in Wantage (see map on back cover). This will act as a focal-point for information and support for anyone evacuated from their home. The centre will also provide a place for school-children and any other family member(s) not present at the time of evacuation to be re-united with their families. Local Authorities will provide food and accommodation at the Rest Centre for evacuated families, although of course if anyone prefers to stay with friends or relatives they are free to do so. If you decide to stay elsewhere, please tell either the police or the staff at the Rest Centre where you are going, so that they can account for everybody from the evacuated area. Please use the Evacuation Registration Form on the Information Card issued with this leaflet for that purpose.

Special arrangements will be made, if needed, by the Local Authorities and the District Health Authorities for the care of elderly, ill, disabled or handicapped people who have to be evacuated.

Looking after your health

The Oxfordshire Health Authority hold stocks of special Iodate Tablets. These tablets provide the protection to people who may have been exposed to radioactive iodine. You may have read about them in the press. They work, in effect, by 'filling up' the thyroid gland with ordinary iodine - the sort that is present in table salt - so that the gland has no room left to take up the radioactive variety. The tablets are very small and the easiest way to take them is with a drink of some sort. They are unlikely to produce any side effects and will not interfere with any other medications.

These tablets will only be issued to those in the affected area on the advice of the Community Physician (Medical Officer for Environmental Health) of the Oxfordshire Health Authority. They would be distributed by authorised personnel carrying proof of identity.

It is possible that you may be advised not to eat locally produced vegetables, fruits and milk for a few weeks after an emergency on site. This is extremely unlikely and you would certainly be given more information and advice if it was considered necessary.

Stock feeding

If you need to go back into the affected area to feed or care for stock animals, horses or ponies, please contact the police, who will make the necessary arrangements.

Summary

The Harwell Laboratory has operated safely for over 40 years. We intend this excellent safety record to continue. However, it is only prudent to develop procedures to be followed in the event of an emergency. This leaflet and the accompanying card are intended as short guides to these procedures. The details of the emergency procedures are in the Emergency Handbook which is in your local library.

If you have any questions regarding the information in this leaflet, please contact the Laboratory and ask for help from the staff in the Public Relations Department.

This leaflet has been produced in conjunction with Local Authorities, the Thames Valley Police and the Oxfordshire Health Authority.

HARWELL LABORATORY EMERGENCY ARRANGEMENTS

Evacuation Registration Form

To be detached and completed in an emergency only.
(Please complete section 1 of this form immediately (and ensure it is always correct)

1.Name of householder.................................
Address...
....
....
Telephone Number................................

If you are advised to evacuate

a) complete sections 2 & 3
b) hand this card to any Police Officer or the staff at the rest centre.

2. Name and address of accommodation to which you are going
....
....
....
....
Telephone No (if known).........................

3. Names of people being evacuated
....
....
....
....

If there is an emergency
You will be contacted by the Police.
This is what you should do:

Go inside
Shut all outside doors and windows
Switch off any fans
Switch on to your local radio station for information

Keep your telephone free for use by the emergency services, unless the call is absolutely necessary. They may need to contact you. Please do **NOT** telephone the laboratory.

If you have to evacuate your home

Here are some suggestions for what to take with you.

A supply of warm clothing
Special food for babies and invalids
Medicines you are using
Personal documents
Any special valuables
The enclosed booklet

Collect these in convenient packages, ready to hand. Don't forget to pack food and a basket for household pets.

Before you leave:

Make sure fires are out
Switch off electrical appliances
Securely lock your property
Take your Evacuation Registration Form with you.

If you want more information, you may like to read the leaflet which accompanies this information card. Or you can consult the more detailed Harwell Laboratory Emergency Handbook (in your local library).

Thank you for reading this card.

Please keep it handy.

QUICK REFERENCE CHECK LIST

In case of evacuation

What to take with you:

- a supply of warm clothing
- special food for babies and invalids
- medicines you are using
- personal documents
- any special valuables
- this leaflet

If advised that you may have to leave your home, collect these in convenient packages.

If you are taking your household pets with you, don't forget food and a basket for them.

What to do before you leave:

- make sure fires are out
- switch off cookers and electrical appliances
- securely lock your property
- take your Evacuation Registration Form with you

APPENDIX 4

The material below is reproduced from 'The Clyde Public Safety Scheme'.

BROADCAST ANNOUNCEMENT (RADIO AND TV)

An announcement in the following form will be released by the Commodore Clyde.

"We have been asked to make the following urgent announcement by ....

An accident has occurred in the reactor plant of a nuclear powered warship berthed at .... which has resulted in the release of a small quantity of radioactive products. There is no possibility of a nuclear explosion occurring. Precautions are being taken in certain areas to protect persons against any risk to their health arising from the release.

The areas affected are ....
....
....

Members of the general public in these areas may be asked to take some protective measures.

Do not move unless requested to do so by the Police. The Police will be acting on the advice of health experts who are already at work assessing the areas affected. In these areas the following precautions should be observed:

Stay indoors as far as possible.

Close all doors and windows.

Do not eat any produce from the garden.

It is perfectly safe to consume any food which is sealed or unsealed food which was inside a building before ....

As a further precaution, persons in the affected area will be offered special tablets to reduce the effects of breathing contaminated air. These tablets are completely harmless and may be taken by children and babies. Full information on how to take them will be supplied with the tablets, which are now being distributed."

The announcement is to be repeated.

APPENDIX 5

The material below is reproduced from 'The Clyde Public Safety Scheme'

POTASSIUM IODATE TABLETS

The instructional leaflet to accompany the issue of Potassium Iodate Tablets to members of the general public following a nuclear reactor accident in which a release of radioactivity has occurred is shown below.

1. There has been an accidental release of radioactivity from a nuclear vessel. The possible harmful effects of the radioactivity can be reduced by taking immediately the tablets supplied to you with these instructions. These tablets are safe and are issued on the authority of the Community Medicine Specialist for your area.

2. The tablets can be taken whole or crushed and swallowed with any suitable drink; they may be more acceptable to babies and children if they are crushed and taken with a spoonful of baby food or jam.

3. The dosage is as follows:

a. Babies up to six months old - half a tablet

b. Infants up to four years old - one tablet

c. Children and adults - two tablets

4. Listen for broadcasts which will be made on the radio and television or for Police announcements in the street. In the meantime for the next few hours you are advised to stay indoors and shut all external doors and windows.

PLEASE DISPLAY THIS NOTICE PROMINENTLY ON THE DOOR OF YOUR HOUSE OR FLAT WHEN YOU HAVE RECEIVED TABLETS FOR ALL MEMBERS OF YOUR FAMILY.

APPENDIX 6

NUCLEAR POWERED SUBMARINE ACCIDENTS

Most of the accident reports listed below are taken from the Greenpeace/Institute for Policy Studies 'Neptune Paper 3' *Naval Accidents 1945-1988*, with slight amendments, others have been added by the author.

June/July 1956 The USS *Seawolf* (SSN 575), the world's second nuclear powered submarine, developed steam leaks during dockside testing after first going critical on 25th June 1956. The plant was shut down and it was determined that the leaks were caused by sodium-potassium alloy which had entered the super-heater steam piping. After repairs and testing, Seawolf began sea trials in January 1957. The sodium-cooled reactor was eventually replaced with a Pressurised Water Reactor in December 1958. [It should be noted that the Soviet Navy still have submarines running with sodium-cooled nuclear reactors].

8th June 1960 Sabotage was suspected in an incident involving damage to a shipyard fire hose used to test the evaporators on board the USS *Nautilus* (SSN 571) while the ship was undergoing overhaul at Portsmouth Naval Shipyard, New Hampshire. The Navy said 'No damage occurred to the ship.'

14th June 1960 The USS *Sargo* (SSN 583) suffered an explosion and fire in its aft end while docked in Pearl Harbor, Hawaii. The fire started from a leak in a high-pressure line that was pumping oxygen aboard. The explosion occurred a few moments later. When dock units and boats were unable to bring the fire under control quickly, officers took the *Sargo* a short distance from the dock and deliberately submerged it with the stern torpedo hatch open to put out the blaze. The Navy said the ship's nuclear reactors were sealed off, and there was 'absolutely no danger of an explosion from the reactor compartment'. The submarine was extensively damaged and was dry-docked, taking three months to repair. The *Sargo* was the first nuclear ship in the Pacific Fleet and was scheduled to take the visiting King and Queen of Thailand on a cruise the next day.

28th November 1960 About this date six men were soaked by reactor coolant while working on the USS *Nautilus* (SSN 571) at Portsmouth Naval Shipyard, New Hampshire. One man accidentally bumped a valve releasing the water onto himself and the others. Clothes and dosimeters were thrown away, making radiation measurements impossible.

2nd November 1961 During its sea trials the USS *Thresher* (SSN 593) docked at San Juan, Puerto Rico. Its reactor was shut down and a diesel generator was started up to provide electricity in keeping with usual docking procedures, but after 7 or 8 hours of operation the diesel generator broke down. While sailors worked on the generator, electricity was provided by an electric storage battery. The generator took much longer than expected to repair, however, and so the decision was made to restart the reactor, the *Thresher's* battery was depleted before the reactor became critical. With no electricity to keep the ventilation system going, the submarine started to heat up. Temperatures in the machinery spaces reached approximately 140°F. Some men were ordered out, suffering from the heat and fumes, and the captain feared that the heat and humidity could damage electrical equipment and lead to a general evacuation. Ultimately the problem was solved by hooking up electrical cables to the diesel-electric powered submarine USS *Cavalla* (SS 244) which was moored alongside early the next morning. With electricity from the *Cavalla*, the *Thresher's* reactor was able to be restarted.

31st December 1961 In 1961, an accident in the nuclear power plant of an early class of Soviet nuclear powered ballistic missile submarine (probably a Hotel Class) reportedly occurred near the coast of England whilst the ship was returning from a training exercise. Crew members were seriously contaminated and parts of the ship and its missiles were also contaminated when a cooling pipe broke. After a 2-month ventilation of the submarine a decision was taken to transfer the missiles to two diesel powered submarines for their test launches.

26th March 1962 HMS *Dreadnought* (S101) suffered a fire in a cabin while the ship was under construction at Barrow-in-Furness.

9th April 1962 The USS *Thomas A. Edison* (SSBN 610) collided with the USS *Wadleigh* (DD 689) during anti-submarine warfare exercises 200 miles east of Norfolk, Virginia. The *Edison's* topside rudder was slightly bent and the destroyer's forward bottom plates were pierced. The *Edison* was repaired at Newport News, Virginia, which took several hours, while the *Wadleigh* went into dry dock for several weeks. According to a navy spokesman the collision resulted from a misunderstanding between the two ships, and occurred as the *Edison* was surfacing. No one was injured.

11th April 1962 Fire broke out in the rudder section of the USS *Thomas A. Edison* (SSBN 610) at Norfolk, Virginia. This fire was caused by the heat from a workman's acetylene torch and was brought under control within 30 minutes.

10th May 1962 The USS *Permit* (SSN 594) was run over by the cargo ship *Hawaiian Citizen* while the *Permit* was on a submerged test run near the Farallon Islands, 30 miles from San Francisco, California. A Navy spokesman said the only damage to the submarine was a bending of the doors to the conning-tower. The crew had to force the doors open to raise the radio antenna to communicate with freighters standing by.

3rd June 1962 The USS *Thresher* (SSN 593) was damaged in a collision with a commercial tug that was berthing it at Port Canaveral, Florida, receiving a 3-foot gash in the submarine's ballast tanks about a foot below the waterline. The submarine went to New London, Connecticut under its own power to effect repairs.

10th October 1962 The USS *Triton* (SSN 586) suffered a fire during repairs in New London, Connecticut. A spokesman for Electric Boat Division of the General Dynamics Corporation said there was only minor damage to one compartment and that no one was injured. He said no radioactivity was involved. The cause of the fire was said to be undetermined.

31st December 1962 During 1962, the engine room of the USS *Skate* (SSN 578) began to flood after a seawater circulation line failed while the submarine was submerged at 400 feet on the way through Baffin Bay off Thule, Greenland. Seawater sprayed in and started to flood the engine room. The submarine did not lose power and surfaced safely. On the surface, with the water pressure greatly reduced, the flooding was successfully stopped.

10th April 1963 The USS *Thresher* (SSN 593) sank in approximately 8,400 feet of water 220 miles east of Boston while conducting post-overhaul trials, killing all 129 men on board. The Navy Court of Inquiry concluded that the most probable cause of the sinking was a flooding casualty in the engine room brought about a piping system failure in one of the submarine's saltwater systems. The *Thresher* has *never been recovered*.

7th May 1963 A fire occurred aboard the USS *Flasher* (SSN 613) at the Electric Boat Shipyard, Groton, Connecticut, killing three and injuring two. Damage to the ship was reportedly negligible. The fire occurred in one of the trimming tanks of the submarine, which was scheduled to be launched on 14th June.

8th May 1963 The USS *Woodrow Wilson* (SSBN 624) suffered a fire while under construction at Mare Island Naval Shipyard in Vallejo, California, injuring three. The fire caused only minor damage to the *Wilson* and occurred when a heavy cable came into contact with a switchboard on the submarine.

7th June 1963 The USS *Tinosa* (SSN 606) collided with the USS *John Adams* (SSBN 620) while being moved in the Portsmouth Naval Shipyard, New Hampshire, when a tug towline snapped. The *Tinosa* received what the Navy said was a 'small dent below the waterline' in the bow.

20th December 1963 HMS *Valiant* (S102), the second Royal Navy nuclear powered attack submarine suffered a fire at the Vickers-Armstrong Yard at Barrow-in-Furness, while the ship was being fitted out after being launched on 3rd December. The fire was in the reactor compartment, in a wooden structure where workers changed their clothing. Mr R.M. Nicholson, the shipyard general manager, said there was no nuclear hazard since the core of the reactor was not installed.

1st July 1964 The USS *Henry Clay* (SSBN 625) ran aground on a shoal in the mouth of the James River and was pulled free an hour later by two tugs. The submarine was en route from Newport News, Virginia across Hampton Roads to pick up Deputy Secretary of Defense Cyrus Vance in Norfolk, Virginia. No damage was reported.

9th January 1965 The USS *Ethan Allen* (SSBN 608) collided with the Norwegian freighter *Octavian* in the eastern Mediterranean while at periscope depth. The US Department of Defense said 'damage was negligible', no casualties occurred, and both the submarine and the freighter continued on their way after exchanging identification.

22nd September 1965 It was announced that HMS *Dreadnought* (S101), Britain's first nuclear powered submarine, was to be withdrawn from service due to metal failures which involved hairline cracks in its internal bulkheads. The submarine returned to service on 2nd February 1966 after modifications to its hull.

13th October 1965 The USS *Barb* (SSN 596) and USS *Sargo* (SSN 583) collided while on manoeuvres 15 miles west of Oahu, Hawaii. Minor damage resulted to the forward end of one submarine and to the mast and sail (commonly referred to as the 'conning tower') of the other. No injuries resulted and both ships returned to port under their own power.

20th December 1965 HMS *Dreadnought* (S101) suffered a fire in its control room while undergoing repairs at Rosyth. It was quickly put out by the crew.

10th August 1966 Cracks in welds were discovered in HMS *Valiant* (S102) during the final stages of its construction at Barrow-in-Furness. British steel firms said the cracks did not represent a serious structural failure and were not dangerous to the vessel or its crew.

10th November 1966 The USS *Nautilus* (SSN 571) collided with the aircraft carrier USS *Essex* (CVS 9) while running submerged about 350 miles north east of Morehead City, North Carolina, during underway replenishment exercises. Both ships returned to port unassisted. The submarine received extensive damage to its conning tower and went to New London, Connecticut. The carrier sustained an open hull cut in the bow area and proceeded to Norfolk, Virginia.

31st December 1966 According to raw CIA intelligence reports, around 1966 a leak occurred 'in the reactor shielding of a [Soviet] nuclear submarine home based in Polyarnyy' on the Kola Peninsula. 'As the submarine entered the port the captain requested permission to proceed directly to the shipyard. Permission was not granted but the captain took the vessel there nonetheless ... A "special brigade" was formed to repair the submarine and part of the crew was sent to a special center on an island near Murmansk where naval personnel with radiation sickness were sent to be treated ... Those sent to the island did not come back.'

31st December 1966 According to raw CIA intelligence reports, the Soviet November Class nuclear powered attack submarine, *Leninskyj Komsomol*, burned near the North Pole some time in 1966-68. 'The accident involved crew members being burned inside a bulkhead that was locked from the outside on both sides. The fire was caused by a spark of oxygen and did not involve the propulsion unit.' The submarine was saved. The submarine 'was one of several submarines which reached the North Pole under ice. The expedition was publicised in the Soviet press at the time without mention of the incident.'

26th May 1967 HMS *Warspite* (S103) suffered a water leak in one compartment while undergoing routine maintenance at Faslane, Scotland. The MoD said the 'defect is not connected in any way with her nuclear plant. Her damage is slight and there are no casualties. The leakage of water was brought quickly under control by *Warspite* herself.'

23rd July 1967 The USS *Greenling* (SSN 614) struck a buoy off Hingham, Massachusetts. There was only minor damage and little interruption to training.

31st August 1967 The USS *Simon Bolivar* (SSBN 641) armed with 16 Polaris missiles collided with the target ship USS *Betelgeuse* (T-AK 260) when practicing a torpedo attack, 70 miles south-east of Charleston, South Carolina. No one was hurt, but the *Bolivar* suffered about $1 million damage to its periscope and communications antennae. The *Betelgeuse* suffered a hole in its hull. The US Navy told a press conference that the missiles aboard the *Bolivar* were not armed and there was no danger of explosion or nuclear radiation. The missiles were undamaged, the Navy emphasised. The *Bolivar* surfaced and the crew cut away a 4-foot high, 15-foot long section of the conning tower so the submarine could proceed to port.

5th November 1967 HMS *Repulse* (S23) ran aground in Walney Channel, Barrow-in-Furness, 30 minutes after its launch at Vickers shipyard, Barrow-in-Furness. Seven tugs were required to pull it free.

24th November 1967 The *Observer* (7/1/68) reported that speculation was circulating that a US nuclear powered ballistic missile submarine suffered serious damage during manoeuvres in northern waters just before Christmas. The US Navy declined to confirm or deny the reports, which came from unidentified sources in Rota, Spain, due to security reasons. In London it was suggested that the damage was caused by pressure changes during a deep dive.

31st December 1967 In 1967 a Soviet November Class nuclear powered attack submarine had a mishap in the Mediterranean believed to be related to its propulsion system.

9th January 1968 *The Times* reported that HMS *Resolution* (S22) recently developed a defect in its electric generator while on its final trials in the Atlantic before test missile firings at Cape Canaveral, Florida. On 8th January the submarine was towed back to Faslane for repairs. UK officials said the repairs would not delay the *Resolution*'s arrival at Cape Canaveral.

30th January 1968 The USS *Seawolf* (SSN 575) ran aground while submerged approximately 65 miles of Cape Cod, Massachusetts, and damaged its rudder. There were no injuries and the submarine returned to Groton, Connecticut for repairs.

18th March 1968 The USS *Theodore Roosevelt* (SSBN 600) ran aground while submerged off the coast of Scotland. There were no injuries, but the bow of the submarine was damaged.

11th April 1968 The USS *Scorpion* (SSN 589) collided with a barge during a storm in Naples harbour, Italy. The submarine was alongside the barge which was used as a buffer between the submarine and another US warship. The barge and the *Scorpion's* stern came together, the barge was swamped and went down. The *Scorpion* returned to Naples on 20th April. Divers descended to untangle a fishing line from its propeller, made a partial inspection of its hull and reported no damage.

27th May 1968 The USS *Scorpion* (SSN 589) sank about 400 miles south-west of the Azores, killing all 99 men on board. The US Department of Defense revealed in 1981 that in the spring of 1968 a nuclear weapon accident occurred in the Atlantic, details of which remain classified. Despite the Pentagon's equivocation, this is taken to refer to the *Scorpion* and it is believed that two nuclear-armed ASTOR torpedoes were on board when the submarine sank.

2nd July 1968 The *Norfolk Ledger Star* reported that several months previously a nuclear powered attack submarine collided with a Soviet submarine, causing severe damage to the US vessel which spent two months in Rota, Spain, for repair. The Navy declined to comment on the story by the paper's military correspondent who quoted a usually reliable source. The reporter noted that it was known that during that period Soviet attack submarines had lain off overseas US Polaris submarine ports, and that US submarines had been given 'wiping off' missions to prevent the Soviet submarines from following the Polaris boats. These missions, apparently, could get quite rough, amounting to what one officer said was 'underwater chicken', with US and Soviet submarines set on collision courses until the 'chicken' turned away. This may have been the cause of the accident.

9th August 1968 The USS *Von Steuben* (SSBN 632) collided with the towed commercial tanker *Sealady* about 40 miles off the southern Spanish coast. The *Von Steuben* was submerged when struck by a submerged tow cable connecting a tug and the *Sealady*. The submarine surfaced immediately and then collided with the towed ship. The submarine sustained minor external damage to the superstructure and main deck.

15th August 1968 Two small fires occurred aboard HMS *Valiant* (S102) while in dock at Chatham Royal Naval Dockyard. Damage to the ship was slight and there were no casualties.

19th October 1968 HMS *Warspite* (S103) was damaged by ice during exercises in the North Atlantic, suffering slight damage to its conning tower and superstructure. The Royal Navy said there was not any risk of 'radioactive leakage.' The submarine returned to Faslane for repairs.

31st December 1968 According to raw CIA intelligence reports, in 1968, a Soviet nuclear submarine sank off Severomorsk on the Kola Peninsula, killing all 90 on board. The submarine was overdue from patrol, and after waiting one or two days authorities initiated a search. Divers found the submarine on the bottom of the estuary of the Kolskiy Zaliv. When the submarine was recovered it was determined that all food had been consumed and it was estimated that the submarine had been at that location for 30 days.

15th May 1969 USS *Guitarro* sank in 35 feet of water while being fitted out at the San Francisco Bay Naval Shipyard. According to a congressional report, the sinking, caused by shipyard workers, was 'wholly avoidable'. The submarine was subsequently raised, damage was estimated at $25 million and the submarine's completion was delayed for two years.

13th October 1969 HMS *Renown* (S26) collided with the Irish motor vessel *Moyle* as it was surfacing during the night near the Mull of Kintyre off the west coast of Scotland. The Navy said damage was slight and at no time was there a risk of a nuclear explosion. There were no casualties. Apparently the *Renown* was carrying out work-up trials preparatory to going on its first operational cruise in a few weeks, but was not carrying any Polaris missiles.

14th November 1969 The *New York Times* (6/7/75) reported that the USS *Gato* (SSN 615) collided with a Soviet submarine on the night of the 14th or 15th November, 15 to 25 miles from the entrance to the White Sea in the Barents Sea. A crew member was quoted as saying the *Gato* was struck in the heavy plating that serves as a protective shield around the nuclear reactor, but the ship sustained no serious damage. However, the ship's weapons officer immediately ran down two decks and prepared for orders to arm a nuclear-armed SUBROC anti-submarine warfare missile and three nuclear-armed torpedoes. According to former *Gato* crewmembers their commanding officer was ordered to prepare false reports showing the submarine had suffered a breakdown and halted its patrol two days prior to the collision. The *Gato's* commanding officer refused to comment when he was contacted, due to security reasons.

10th January 1970 HMS *Dreadnought* (S101) encountered serious problems at HM Royal Naval Dockyard, Rosyth during the first nuclear reactor refuelling operation in Britain. The problems delayed the completion of the refit for at least ten months.

29th January 1970 The USS *Nathanael Greene* (SSBN 636) was grounded for seven hours in thick fog in Charleston harbour, South Carolina. The US Navy closed the harbour while the submarine was refloated. Officials would not say whether there were any Polaris missiles on board, but a Navy spokesman did say that there appeared to be no danger of nuclear leakage or reactor damage, The next day the Navy said the ship suffered no damage.

12th April 1970 A Soviet November Class nuclear powered submarine sank in the Atlantic Ocean approximately 300 miles northwest of Spain. On 11th April the submarine was sighted dead in the water with personnel on deck trying to rig a tow line to two accompanying Soviet ships. By the morning of 12th April US Navy P-3 Orion patrol planes could only find two oil slicks on the surface where the submarine had been, the submarine was considered to be lost at sea. The accident was believed to have been related to a problem in the nuclear propulsion system. After the sinking, Soviet survey vessels reportedly guarded the area almost continuously for six months. Thereafter, routine patrols were conducted until 1979, after which only occasional visits were made.

28th May 1970 The USS *Daniel Boone* (SSBN 629), whilst proceeding on its initial sea trials, collided with the Philippine merchant ship *President Quezon* off Cape Henry, Virginia. The submarine incurred minor damage, but the *President Quezon* received extensive damage to its bow.

30th July 1970 Suspected sabotage to the main gearbox of HMS *Conqueror* (S48) while in the final stages of completion at the Cammel Laird Shipyard, Birkenhead was under investigation. The shipyard said that the damaged gearbox did not affect nuclear safety as it was separated from the reactor compartment.

11th September 1970 HMS *Dreadnought* (S101) suffered an air pipe fault, delaying its sea trials.

14th November 1970 The USS *Seawolf* (SSN 575) suffered a breakdown in its engine room main drain, while south of Guantanamo Bay, Cuba en route to the Pacific. It surfaced dead in the water and asked for assistance. The USS *Blandy* (DD 943) got under way to rendezvous and escort or tow the submarine. The next day the submarine was able to correct the problem itself and got under way for Guantanamo under its own power.

29th November 1970 A fire broke out in the baggage storage room in the stern of the submarine tender USS *Canopus* (AS 34) while in the Holy Loch. The *Daily Telegraph* reported that it was carrying nuclear-armed missiles and that two US nuclear powered ballistic missile submarines, the *Francis Scott Key* (SSBN 657) and *James K Polk* (SSBN 645) were moored alongside. The *Francis Scott Key* cast off, but the *Polk* remained alongside. US naval authorities at the Holy Loch and London dismissed any suggestion that a nuclear explosion aboard the *Canopus* could have occurred or that 'even a remote danger' from missiles or other materials existed. 'We have drills and precautions which rule out any danger whatsoever', the London spokesman said. 'There are precautions against every eventuality in the Holy Loch.' The fire was brought under control after four hours. Three men were killed and the cause of the fire was unknown. US Navy documents record that 'damage was extensive in the small area in which the fire was contained', but repairs were effected on site and *Canopus* was never 'off the line'.

2nd February 1971 The French nuclear powered ballistic missile submarine *Redoubtable* collided with a fishing vessel off Brest, France. The trawler was holed, but the crew was safely picked up by a French Navy escort vessel.

3rd March 1971 HMS *Conqueror* (S48) suffered flooding due to a failure of material while in a fitting-out basin in the Cammel Laird shipyard. Firemen and yardworkers spent about 17 hours pumping 7 feet of water out of the submarine.

24th February 1972 A US Navy P-3 Orion patrol plane sighted a Soviet Hotel II Class nuclear powered ballistic missile submarine on the surface 600 miles north-east of Newfoundland. The submarine had an apparent nuclear propulsion problem which resulted in the loss of all power. Several deaths are thought to have occurred. The next day the US Coast Guard cutter *Boutwell* sighted the disabled submarine in the company of five Soviet ships. An offer of assistance by the *Boutwell* received no reply. The Soviet ships started back to the submarine's home base through heavy, stormy seas. On 18th March the submarine was still slowly moving across the north Atlantic now accompanied by nine Soviet ships and the US coast Guard cutter *Gallatin*. On 5th April the West German Navy reported that the submarine had reached its home waters in the White Sea.

4th November 1972 The USS *Benjamin Franklin* (SSBN 640) collided with and sank a tugboat at the General Dynamics Electric Boat Division docks at Groton, Connecticut. The submarine was not damaged.

6th October 1972 The USS *Tullibee* (SSN 597) collided with the West German freighter *Hagen* as it was cruising just beneath the surface about 150 nautical miles east of Cape Hatteras, North Carolina, during stormy weather, causing slight damage to the submarine. The collision did not impair the operations of either ship.

25th October 1972 The USS *Snook* (SSN 592) was slightly damaged when it struck bottom in Dabob Bay, Washington, whilston a celebration run. The submarine surfaced without any problems.

1st December 1972 According to raw CIA intelligence reports, in December a Soviet nuclear powered submarine from the Northern Fleet suffered a nuclear radiation accident whilst on patrol off the eastern coast of North America. The accident involved leakage from a nuclear-armed torpedo in the Mine-Torpedo Department in the forward section of the submarine. Reportedly, 'Doors were immediately secured in accordance with regulations and some crew members were trapped within the space where the nuclear radiation leakage occurred.'

31st December 1972 According to raw CIA intelligence reports, an undetermined accident during Soviet naval operations crippled a Soviet nuclear powered submarine in the Atlantic, probably in December 1972 or January 1973. Reportedly, the submarine was towed 'at a speed of two to three knots for six weeks to Severomorsk, crew members were permitted [to disembark] the submarine. Several men died shortly after the accident, others later ... The majority of the submarine crew members suffered from some form of radiation sickness.'

22nd January 1973 The USS *Batfish* (SSN 681) suffered bottom damage after running hard aground at Charleston, South Carolina while proceeding to sea. The submarine was pulled free by tugs and returned to dock.

27th March 1973 The USS *Hammerhead* (SSN 663), operating east of the Virginia Capes area at about 300 feet, struck a submerged object of unknown nature thought to be non-metallic, perhaps a whale. The impact was heavy enough to be heard and felt throughout the ship. There was no discernible damage.

27th March 1973 The USS *Greenling* (SSN 614) went below its safe diving level while training about 250 miles north-west of Bermuda, because the needle on the depth gauge stuck. The true depth was disclosed on another gauge before the submarine reached a depth that would have crushed its hull. On 30th March it arrived at its homeport of Groton, Connecticut. On 10th April it docked at Portsmouth Naval Shipyard, New Hampshire for a thorough check.

21st April 1973 The USS *Guardfish* (SSN 612) suffered a primary coolant leak while running submerged about 370 miles south-south-west of Puget Sound. The submarine surfaced and was ventilated and decontaminated. They repaired the leak unassisted. Four crewmen were transferred to the Puget Sound Naval Hospital for monitoring.

21st May 1973 The USS *Sturgeon* (SSN 637) struck the bottom of the ocean, suffering minor damage, while operating in deep water during a dive off the US Virgin Islands. The US Navy said there were no injuries to the crew and the submarine's nuclear propulsion plant was not affected. The submarine put in to the nearest US port at Frederiksted, St Croix, under its own power.

6th June 1973 The USS *Skipjack* (SSN 585) hit an uncharted undersea mountain during 'Dawn Patrol' exercises in the Mediterranean Sea. The submarine suffered minor damage and proceeded on the surface to Souda Bay, Crete, for hull inspection.

5th September 1973 The US Defense Department reported that a damaged Soviet Echo II Class nuclear powered cruise missile submarine had been sighted in the Caribbean south of Cuba with an 8-foot gash in the port bow deck. This was apparently the result of a collision with another Soviet ship during manoeuvres of the Soviet Caribbean task force. A Pentagon spokesman said that the submarine did not appear to be in danger of sinking.

17th April 1974 HMS *Renown* (S26) struck the seabed while carrying out an exercise in the Firth of Clyde. The submarine had just completed an expensive refit in Rosyth but was not carrying nuclear weapons. The captain, Robin Whiteside, faced a court martial on 11th June.

19th September 1974 HMS *Renown* (S26) suffered a steering defect while on the surface during exercises off the west coast of Scotland. On 23rd September the ship was towed from the Royal Naval Armaments Depot at Coulport to the submarine base at Faslane for investigation and repair.

3rd November 1974 The USS *James Madison* (SSBN 627) collided with an unknown Soviet submarine in the North Sea. The collision left a 9-foot scrape on the *Madison*. According to Anderson the two submarines came within inches of sinking one another. The *Madison* proceeded to the Holy Loch to effect repairs. The US Navy refused to comment on the incident.

16th February 1975 The USS *Swordfish* (SSN 579) ran aground near Lanai, Hawaii, while carrying out post-overhaul trials. The submarine surfaced safely and returned to Pearl Harbor for inspection and repair. The Navy said the submarine damaged sensor devices mounted on the hull, but there were no breaks in the hull. The *Honolulu Star Bulletin*, however, received reports that a torpedo room had flooded. The Navy denied this.

24th March 1975 The USS *Dace* (SSN 607) collided with a fishing vessel while surfaced in the Narraganset Bay area off Rhode Island. There was no reported damage to the submarine.

2nd May 1976 HMS *Warspite* (S103) suffered a fire in a diesel generating room while berthed in the Royal Seaforth Docks, Crosby, Liverpool. Three people were injured in the blaze. The Ministry of Defence said 'There was absolutely no nuclear hazard.' Originally it was anticipated that its patrol would be delayed one week. However, in January 1979 it was reported that the fire was caused by the failure of a coupling on a lubricating oil pipe, which allowed oil to be sprayed over a diesel generator. Repairs were continuing three years later at a cost of £5,194,000.

28th August 1976 A Soviet Echo II Class nuclear powered cruise missile submarine struck the USS *Voge* (FF 1047) with its sail, on the port quarter below the helicopter hangar, about 150 miles southwest of Souda Bay, Crete. The submarine departed the area under its own power to the Kithera Anchorage off Greece escorted by Soviet ships. The *Voge* suffered split bulkheads, buckled plating and a damaged propeller, and was towed to Souda Bay by the *Moinster* (FF 1097) and *Preserver* (ARS 8). The submarine damaged its sail. In September the *Voge* was towed to Toulon, France. On 7th September the US State Department announced that the US and Soviet Union had exchanged notes, each blaming the other for the collision.

6th August 1977 A major 'class Bravo' fire occurred in the forward engine room of USS *Hunley* (AS 31) while the ship was part of the Atlantic Fleet.

> *The excellent response of the Duty Damage Control Party and action of other individuals on board limited the fire to the forward engine room and extinguished it 25 minutes from its start. Fire, smoke and/or firefighting water damaged the Number 2 main engine, Numbers 1 and 2 main propulsion generators, Numbers 1 and 2 ship service*

generators, Numbers 1 and 2 low pressure air compressors, Number 2 force draft blower, Number 2 evaporator and salinity indicating system, plus runs of electrical cable in the vicinity of the fire. The forward switchboard, 1S, was grounded by firefighting water, rendering the forward part of the ship without normal electrical power.

20th September 1977 The USS *Ray* (SSN 653) struck the bottom south of Sardinia, Italy, damaging its bow area. The *Ray* surfaced and proceeded to La Maddalena US naval base on Sardinia, escorted by the USS *Grayling* (SSN 646).

29th September 1977 The USS *Archerfish* (SSN 678) and the USS *Philadelphia* (SSN 690) collided stern to stern at slow speed at the Groton submarine base, Connecticut, with minor damage reported.

6th December 1977 The USS *Pintado* (SSN 672) sustained minor damage to the top of its rudder in a minor collision with a South Korean Navy ship during exercises off Korea. The *Pintado* initiated emergency deep-dive procedures when the surface ship turned towards the submarine at close range.

31st December 1977 According to raw CIA intelligence reports, in 1977 a Soviet nuclear powered submarine suffered an internal fire while in the Indian Ocean. The submarine was forced to the surface in an attempt to fight the fire, which took several days to extinguish. A Soviet trawler subsequently towed the submarine to a port near Vladivostok.

31st December 1977 Some time during 1976-77, HMS *Repulse* (S23) suffered a fire, causing £200,000 damage.

23rd May 1978 While workers were draining a piping system aboard the USS *Puffer* (SSN 652), radioactive water spilled on the dry dock surface at the Puget Sound Naval Shipyard, Bremerton, Washington. A Navy spokesman said that 'less than 5 gallons' of slightly radioactive water spilled as the workers were draining the liquid into two 5-gallon liquid containers, a routine operation. The spill, said the Navy, was due to the inattention of the personnel doing the draining. The water being drained was reportedly part of the submarine's secondary cooling system. The dry dock drain was contaminated, but was closed before any spillage escaped into the sea. According to the Navy, no workers were contaminated. Shipyard employees disputed the Navy's account, saying that the spill was much bigger, about 100 gallons, that response to the spill was slow, and that several workers suffered skin contamination. These reports could not be verified. Subsequently a contaminated 15 by 20-foot section of dry dock was jackhammered up, sealed in drums and shipped to a nuclear waste site in Hanford, Washington.

16th June 1978 The propeller shaft of the USS *Tullibee* (SSN 597) snapped just outside the hull causing limited engine room flooding and loss of propulsion while it was submerged in the Mediterranean. The flooding was stopped by the tightening of the emergency packing on the propeller shaft. The submarine quickly surfaced and was assisted by other US Navy vessels. Subsequently, it was towed to Rota, Spain, for repairs.

19th August 1978 A Soviet Echo II Class nuclear powered cruise missile submarine was sighted dead in the water near Rockall Bank, 140 miles north-west of Scotland, after experiencing problems with its nuclear power plant. On 20th August a US P3 Orion aircraft observed the submarine under tow to the Soviet Union south of the Faroe Islands. The exact cause of the problem and the number of possible casualties remains unknown.

December 1978 Since this date defects have been found in the General Electric Company's turbines installed in 14 of the Los Angeles class of submarines. Repairs to rectify the problem cost $3 million for each submarine. In addition, those submarines, fitted with General Electric turbines, had speed restrictions placed upon them until they were inspected. The fault was also discovered in the turbines supplied for the USS *Ohio*, delaying its commissioning date.

17th January 1979 A mechanic who helped to contain a steam burst after an explosion in the engine room of HMS *Revenge* (S27) won the Queen's Gallantry Medal. He crawled along a foot-wide catwalk below a hot cloud of escaping high-pressure steam as he searched for the leak in the turbo-generator room.

27th April 1979 The USS *Pargo* (SSN 650) was briefly grounded while entering New London harbour, Connecticut, in heavy fog.

11th May 1979 Primary coolant water leaked from one of the two reactors aboard the USS *Nimitz* (CVN-68). A Navy spokesman said there was no release of radioactivity, no danger to the core, and no danger to the ship's crew. The ship was operating off the Virginia coast.

24th May 1979 The USS *Andrew Jackson* (SSBN 619) incurred slight damage to its rudder when it ran aground briefly while entering New London harbour, Connecticut, in reduced visibility.

4th June 1979 The USS *Woodrow Wilson* (SSBN 624) ran aground in heavy fog at Race Rock while en route to New London, Connecticut. The submarine backed off and proceeded to port for inspection and damage assessment.

12th June 1979 A Mk48 conventional torpedo jammed between loading equipment and a bulkhead when a chain broke on a loading mechanism, allowing the torpedo to drop several feet aboard the USS *Memphis* (SSN 691), docked at the Norfolk Naval Station, Virginia. The torpedo was removed two days later. It did not have a triggering device, but Navy sources said that had it exploded it could easily have sunk the submarine.

20th June 1979 The USS *Hawkbill* (SSN 666) reactor's primary coolant system developed a leak while the submarine was on manoeuvres in Hawaiian waters. The leak lasted for two days. Originally the leak was about 2 gallons an hour, but by the time the submarine docked in Pearl Harbor, Hawaii, on 23rd June, the leak had been reduced to three US quarts an hour. On 24th June it stopped. The Navy said that none of the water escaped as it was captured and stored in tanks designed for such contingencies, and that none of the crew was in danger. Supplemental cooling water was pumped in to prevent overheating. According to the Navy, 'The leakage was caused by normal wear of inside parts of valves. Such leaks happen occasionally.'

20th July 1980 The USS *Gurnard* (SSN 662) spilt 30 gallons of water containing radioactive material into San Diego Bay, California. A Navy spokesman said that the leak occurred when a crewman of the *Gurnard* accidentally opened a valve allowing the water to escape, that a water sample was taken and there was no increase in the general background radiation level in the area where the spill happened.

12th August 1980 HMS *Sovereign* (S108) broke down during routine tests in Plymouth Sound. According to the Royal Navy the breakdown was caused by a 'minor mechanical defect'. The submarine was towed back to Devonport Dockyard.

21st August 1980 A Soviet Echo Class nuclear powered submarine suffered a serious casualty and lost power about 85 miles off the east coast of Okinawa. At least nine crew members were believed to have died from a probable fire in the propulsion spaces. A Soviet freighter arrived to evacuate the crew and a tugboat was readied to tow the submarine to Vladivostok, escorted by several warships. The next day Japan advised ships to avoid the area, citing possible radiation leaks and refused to allow the submarine to pass through Japanese territorial waters unless Moscow guaranteed that there were no nuclear weapons on board and no danger of radiation leaks. The Soviets initially refused to guarantee the safety of the reactor and entered Japanese waters despite Japan's warnings. But on 24th August Moscow acquiesced to Japan's demands concerning safety, and informed Japan that there was no radioactive leakage or nuclear weapons on board. Subsequently, Japanese examinations of the air and water in the area of the accident reportedly found evidence of radioactive contamination.

1st December 1980 In December HMS *Dreadnought* (S101) suffered serious machinery damage - reportedly cracks in the secondary cooling system - which necessitated a complete reactor shutdown. This damage and troubles with scheduling a refit led to a decision to retire the ageing submarine.

3rd December 1980 During a test, about 150 gallons of low level radioactive water leaked from a faulty valve on the USS *Hawkbill* (SSN 666) while undergoing overhaul at the Puget Sound Naval Shipyard, Washington. Five workers received low-level radioactive contamination. A Navy spokesman said that they received a dose of radiation 'less than that typically received by a chest X-ray'.

9th April 1981 The USS *George Washington* (SSBN 598) collided with the 2,350-ton Japanese freighter *Nissho Maru* in the East China Sea about 110 miles south-south-west of Sasebo, Japan. As it was surfacing, it ran into the underside of the freighter, damaging its hull and causing it to sink in 15 minutes, killing two Japanese crewmen (13 others were rescued). The submarine suffered minor damage to a small section of its sail.

15th May 1981 A hairline crack was discovered in the main cooling system of HMS *Valiant* (S102) as it returned to Devonport after developing a fault in its cooling system while operating off the Cornish coast. The crack did not affect the operation of the reactor and the vessel returned to Devonport under its own power. The Royal Navy denied claims that contaminated water was discharged into Plymouth Sound saying 'A very small quantity of water leaked out and this was drained off into a lead tank in a barge for treatment.' The reactor was cooled down before the leak was plugged.

2nd November 1981 At the Holy Loch naval base a Poseidon submarine-launched ballistic missile was dropped 13 to 15 feet due to an error by a crane operator as it was being moved onto the submarine tender USS *Holland* (AS 32).

22nd March 1982 The USS *Jacksonville* (SSN 699) collided with the Turkish cargo ship *General Z. Dogan* while running on the surface 25 miles east of Cape Charles, Virginia. Damage to the *Jacksonville* was reported as minor and characterised as 'bumps and scrapes', while bow damage was reported on the *General Z. Dogan*.

19th August 1982 A Royal Navy board of inquiry was established to investigate damage to HMS *Revenge's* (S27) gearbox caused by the presence of a small, extraneous piece of metal as the submarine was nearing the end of a 2½-year major refit at Rosyth, Scotland. The damage delayed the submarine's scheduled completion date.

28th September 1982 The USS *Sam Houston* (SSN 609) spilt less than 50 gallons of low-level radioactive water during a test whilst in the Puget Sound Naval Shipyard, Bremerton, Washington. It was undergoing routine maintenance. According to the Navy, the spill was stopped, the water was contained within the ship and no radioactivity was released to the environment. The submarine's reactor was not operating. Two people were in the vicinity of the spill and one received low-level radioactive contamination.

29th November 1982 The USS *Thomas A Edison* (SSN 610) collided with the USS *Leftwich* (DD 984) in the South China Sea 40 miles east of Subic Bay, Philippines. The *Edison* was at periscope depth preparing to surface; it damaged its sail and diving planes, but there was no flooding. Both ships remained operational after the accident.

31st December 1982 In late 1982 the USS *Permit* (SSN 594), cruising on the surface, collided with the USS *La Jolla* (SSN 701), at periscope depth, while they were on sea trials about 30 miles off San Francisco. The *Permit* received a 10-foot long, 3-foot wide 'scrape' in the paint on its keel, while the *La Jolla* suffered minor rudder damage.

1st June 1983 In June a Soviet Charlie Class nuclear powered cruise missile submarine sunk somewhere east of the Soviet naval base of Petropavlosk, near the southern tip of the Kamchatka peninsula in the Pacific. US intelligence reports reported that most or all of the 90-person crew were lost. The cause of the accident is not known, but the lack of radioactive contamination is said to indicate that the accident was probably due to mechanical failure, not a nuclear power plant accident. The submarine was salvaged by the Soviet Navy in early August 1983.

18th September 1983 HMS *Conqueror* (S48) suffered a fire while in dry dock in Devonport for a refit. No injuries were reported.

19th December 1983 The USS *Florida* (SSBN 728) was slightly damaged when it hit an unidentified object while submerged during sea trials in Long Island Sound.

2nd April 1984 The *Glasgow Herald* reported that the US Navy at the Holy Loch admitted that paint on the USS *Sam Rayburn* (SSBN 635) was mildly radioactive when it returned from patrol in February 1984. the Navy said that the level of radioactivity was so low it could not be measured on a geiger counter.

18th August 1984 A fire reportedly broke out on board the dry dock at Faslane while the USS *Nathanael Greene* (SSBN 636) was in the dock for repairs. A Ministry of Defence official said the fire was caused by an electrical fault in a capstan motor which ignited a small quantity of canvas on top of the motor. He denied that the fire threatened the submarine since it broke out in a sealed compartment some distance from it.

18th September 1984 A Soviet Victor I Class nuclear powered attack submarine was badly damaged in a collision with a Soviet tanker in the Strait of Gibraltar. The submarine was reportedly travelling in the 'noise shadow of the tanker while exiting the Mediterranean Sea'. *Jane's Defence Weekly* noted that the alternating layers of cold and warm water in the narrows of the Strait make it likely for a submarine 'to encounter sudden thermal gradients which make her porpoise upwards', and this is thought to have been the cause of the accident. The collision ripped off the twin-hulled submarine's bow section, exposing the sonar and torpedo tube compartments. The submarine proceeded to the Soviet anchorage at Hammament, Tunisia, for emergency repairs, before returning to its homeport on the Kola peninsula in early October.

21st September 1984 The USS *Jacksonville* collided with a Navy barge off Norfolk, Virginia, while travelling on the surface. The *Jacksonville* struck the barge amidships and was reported to have caused minor damage to its bow.

10th June 1985 HMS *Resolution* (S22) was struck by the US yacht *Proud Mary* off Cape Canaveral, Florida. The submarine suffered minor damage, the yacht had to be towed back to port.

24th October 1985 The USS *Swordfish* (SSN 579) suffered a 'propulsion casualty' whilst operating as part of the US Pacific Fleet.

31st December 1985 The USS *Narwhal* (SSN 671) drifted for several hours in Palma Bay, Palma Majorca, Spain, after its mooring cable broke.

13th January 1986 A Japanese maritime patrol aircraft spotted a Soviet Echo II Class nuclear powered cruise missile submarine under tow by a Soviet salvage ship about 280 miles north-west of Okinawa in the East China Sea, heading northward. The submarine evidently suffered a 'propulsion casualty'.

13th March 1986 The USS *Nathanael Greene* (SSBN 636) ran aground in the Irish Sea, suffering external damage to its ballast tanks and rudder. A spokesman for the US Navy said 'There was no effect on the propulsion, no injuries and no damage to the Poseidon nuclear missiles.' The submarine sailed to the Holy Loch under its own power for emergency repairs. It left there on 25th April and travelled submerged to Charleston, South Carolina. The extent of the damage subsequently led to a decision to decommission the vessel, partly in order to satisfy SALT II limitations.

3rd October 1986 A Soviet Yankee Class nuclear powered ballistic missile submarine suffered an explosion and fire in one of its missile tubes 480 miles east of Bermuda, killing at least three. General Secretary Gorbachev sent President Reagan a private communication regarding the accident in advance of a public announcement on 4th October, assuring him that there was no danger of nuclear explosion, radioactive contamination, or accidental launching of nuclear missiles. US forces sampled the air and water around the submarine and detected no radioactivity. The submarine sank under tow on 6th October in 18,000 feet of water about 600 miles north-east of Bermuda. US sources said that the explosion probably originated in the liquid fuel of one of the missiles.

31st October 1986 In late October the *USS Augusta* (SSN 710) was damaged in an undersea collision while on a routine training patrol in the Atlantic. No crew members were injured and the submarine returned to Groton, Connecticut for repairs.

25th April 1987 The USS *Daniel Boone* ran aground in the St James River at Newport News, Virginia, during sea trials following a $115 million overhaul. The grounding delayed the ship's return to service.

30th June 1987 In late June or early July the USS *Nevada* (SSBN 733) suffered a breakdown while conducting routine operations following the improper installation of a power transmission gear during a recent February to April maintenance stop at the Newport News shipyard, Virginia. The damage was estimated at several million dollars.

26th August 1987 HMS *Conqueror* (S48) suffered a fire while at Devonport for a 4-month overhaul, damaging its engine room. The Navy stressed that the fire was far from the submarine's nuclear reactor.

1st October 1987 HMS *Renown* (S26) suffered a leak of reactor coolant during tests in the reactor compartment while at Rosyth for a refit. The Navy said it was a minor incident 'without any radiation hazard'.

26th January 1988 HMS *Resolution* (S22) suffered an electrical malfunction while docked at Faslane. The *Observer* newspaper claimed that the malfunction shut down the primary coolant pumps, almost leading to a core meltdown,. and that a crew member who was exposed to radiation had to be scrubbed down for 24 hours. The Ministry of Defence denied these stories, saying the submarine suffered a 'minor electrical malfunction', that those who said that the submarine's reactor could melt down didn't know what they were talking about, and that there had been 'absolutely no danger to the crew or the general public'.

28th February 1988 It was reported in the *Sunday Mail* that rust in the reactor piping of HMS *Valiant* (S102) had crippled it whilst it was in refit at Rosyth Naval Dockyard. Corrosion and radioactive contamination on pipes leading from the submarine's reactor was so bad that engineers could not get close enough to replace them, and Rolls-Royce would have to develop remote-controlled robots to carry out the necessary repairs. Despite the fact that an official of Babcock Thorn, who manage Rosyth Dockyard, said 'We are not in the business of sending that boat out when we have people's lives at risk' the MoD said the problems were 'minor', and to be expected in an old submarine.

29th April 1988 The USS *Sam Houston* (SSN 609) ran aground in Carr Inlet off the south-east tip of Fox Island in Puget Sound, Washington, while operating in shallow water to determine how quiet the vessel was in water. The submarine was freed the next day by four tugs and the USS *Florikan* (ASR 9), while the submarine's 142-man crew remained on board. The submarine suffered minor damage to exterior hull equipment.

17th May 1988 HMS *Conqueror* (S48) suffered a fire while docked in Gibraltar. The flames were quickly put out and did not affect the nuclear reactor.

1st June 1988 In the first week of June HMS *Conqueror* (S48) was accidentally hit by an unarmed training torpedo dropped by an anti-submarine warfare helicopter during exercises off the west coast of Scotland. The deck plating of the submarine was bent on impact and the submarine went to Faslane for repair.

2nd July 1988 HMS *Courageous* (S50) collided with and sank the privately chartered yacht *Dalriada* at night in the North Channel of the Irish Sea. The four persons on the yacht were rescued by HMS *Battleaxe* 35 minutes later.

7th December 1989 A pipe connecting *HMS Talent* (S92) to a 'nuclear facilities' barge broke, spilling 30 gallons of slightly radioactive water into the Thames Dock at Barrow-in-Furness.

January/February 1990 It was revealed that during the final stages of the refit of HMS *Warspite* at Devonport Dockyard, cracks were found in the cold water return loop of the submarine's nuclear reactor. As a result of this all Valiant Class submarines were recalled to port. Such a development was not wholly unexpected in boats that were all over 20 years old. After years of bombardment by radiation, steel becomes brittle and vulnerable to cracking. These cracks could easily lead to a loss of coolant accident which could lead to a large-scale release of radioactivity to the environment and the loss of the submarine. As of the end of March 1990 no Valiant Class submarines have been sent out on patrol since the problem came to light, but the Polaris boats still remain active. The MoD says that it will only inspect submarines as they come in from routine patrols and it is unclear what work is under way to solve this serious problem.

8th **March 1990** Water was spotted leaking from 'test equipment' attached to the primary coolant circuit of HMS *Sceptre* (S104) whilst it was in refit at Devonport Dockyard.

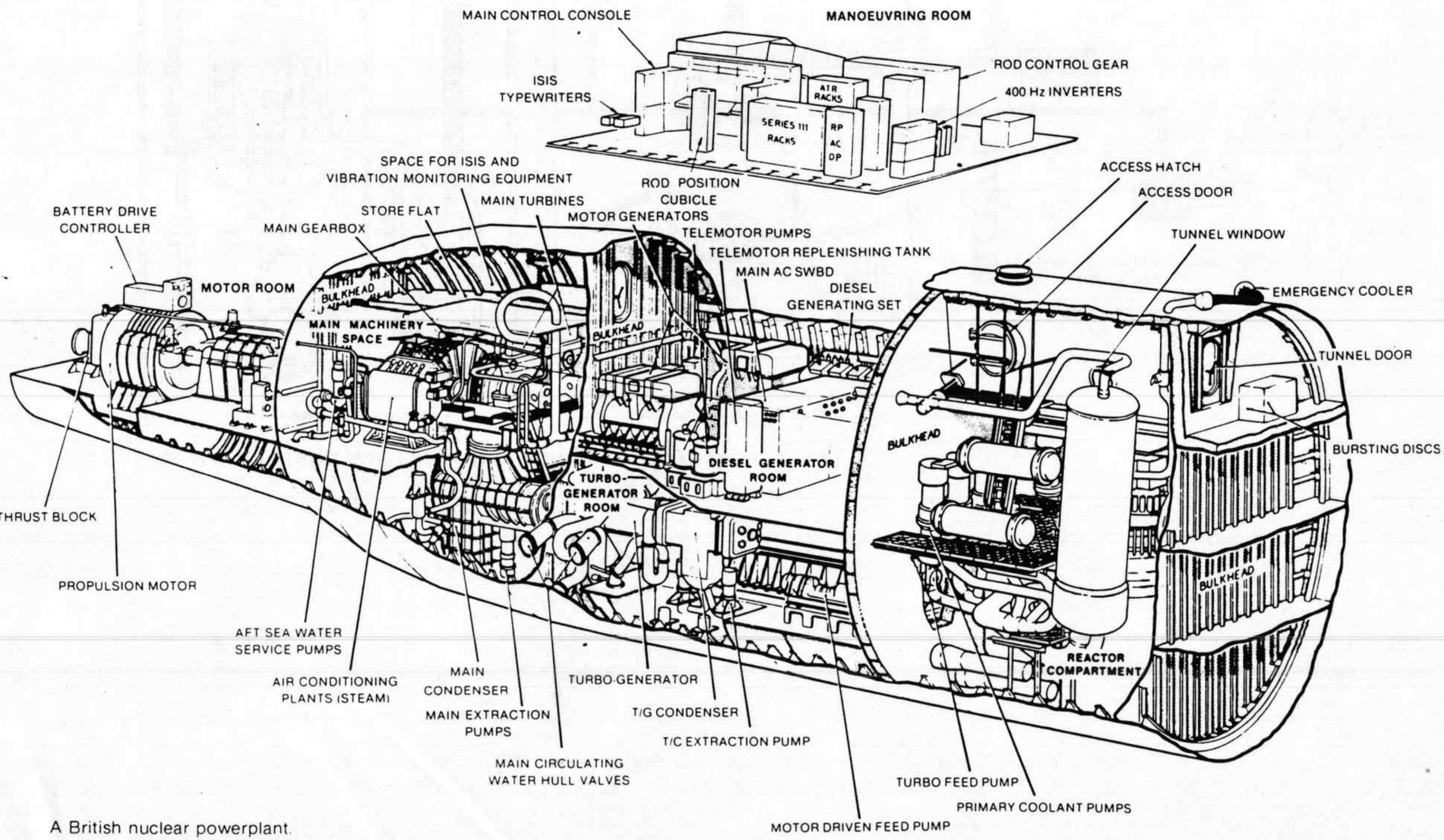
Undated - but after 1964 when it was commissioned - The USS *Von Steuben* (SSBN 632) suffered a 'reactor scram' while its diesel engine was disassembled for maintenance. Large amounts of electricity were needed for a reactor restart, and the battery was exhausted without restarting the reactor. The submarine wallowed on the surface for at least several hours while the diesel generator was reassembled by flashlight.

Undated - but seemingly in the 1950s or early 1960s - The USS *Nautilus* (SSN 571) suffered an involuntary reactor shutdown which took 24 hours to overcome, during which it only had diesel engine power.

APPENDIX 7

THE ROYAL NAVY'S NUCLEAR POWERED SUBMARINES

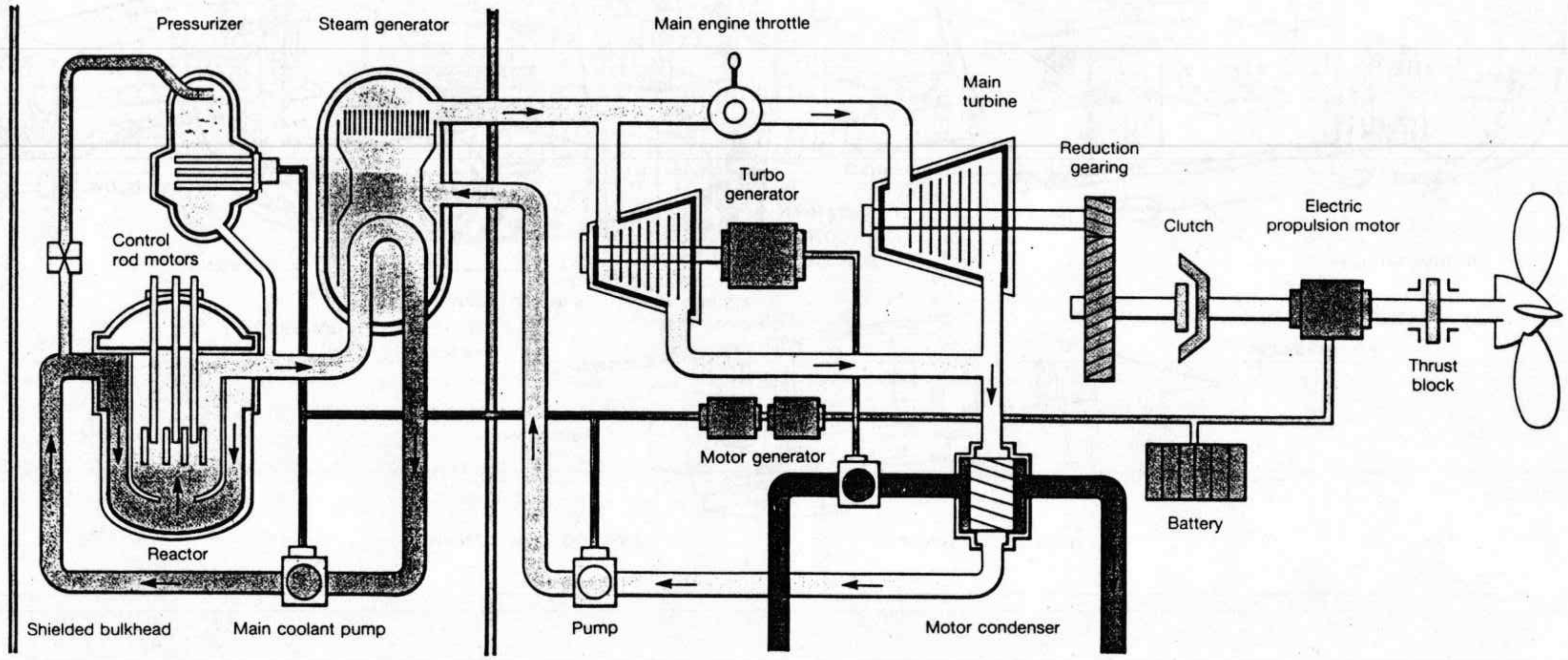
Name	Type	Entered service
Dreadnought	SSN	1963 [decommissioned 1982]
Valiant	SSN	1966
Warspite	SSN	1967
Resolution	SSBN	1967
Renown	SSBN	1968
Repulse	SSBN	1968
Revenge	SSBN	1969
Churchill	SSN	1970
Conqueror	SSN	1971
Courageous	SSN	1971
Swiftsure	SSN	1973
Sovereign	SSN	1974
Superb	SSN	1976
Sceptre	SSN	1978
Spartan	SSN	1979
Splendid	SSN	1981
Trafalgar	SSN	1983
Turbulent	SSN	1984
Tireless	SSN	1985
Torbay	SSN	1987
Trenchant	SSN	1989
Talent	SSN	[laid down 1986]
Triumph	SSN	[laid down 1986]
Vanguard	SSBN	[laid down 1986]
Victorious	SSBN	[laid down 1987]



A British nuclear powerplant.

FIGURE ONE

Pressurised-water nuclear propulsion system layout



SECTION 5

COMMUNITY MEDICINE SPECIALISTS

(1) ARGYLL & BUTE DISTRICT

Dr L M St G Wertheim
Tigh-na-Linne
Lochgilphead — Telephone: Lochgilphead 2511 or Dumbarton 61321
Out of Hours: Rhu 820262

(2) DUMBARTON DISTRICT

Dr J Young
Westonlee House
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Out of Hours: 041-942-2535

NOTE: (1) acts as alternative Community Medicine Specialist for (2).

(3) RENFREW DISTRICT

Dr Logan
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(4) INVERCLYDE DISTRICT

Dr G S Carrick
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Greenock — Telephone: 0475-25322

(5) CUNNINGHAME DISTRICT

Dr W J Patterson
Community Medicine Specialist (Environmental Health)
Ayrshire and Arran Health Board
Community Medicine Department
Ayrshire General Hospital
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NOTE: If Dr Patterson is not available, the name and telephone number of the Community Medicine Specialist on duty may be obtained from the switchboard operator at Crosshouse Hospital telephone number 0563-21133.