Australian Government

RADIATION MONITORING HANDBOOK for VISITS BY NUCLEAR POWERED WARSHIPS TO AUSTRALIAN PORTS

prepared by Brian Holland

Australian Nuclear Science and Technology Organisation

on behalf of the

Visiting Ships Panel (Nuclear)

Department of Defence

Version 2.0

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1. INTRODUCTION

Nuclear powered warship (NPW) vessels from friendly nations visit Australian ports for re-supply and to provide the crews with "rest and recreation". Radiation safety and monitoring requirements for these visits are detailed in the Department of Defence Operations Manual (OPSMAN 1), "Visits to Australia by Nuclear-Powered Warships" (ref 1). These requirements include the need for each port to have a Port Safety Plan in place and for radiation monitoring to be carried out during the visit and in the event of damage to the nuclear reactor.

To support the Port Safety Plans, Commonwealth and State/Territory organisations provide personnel to carry out radiation monitoring and advice to Emergency Managers, of the significance of the monitoring results and of any protective measures that should be taken to protect people.

A Leader of the Radiation Monitoring Group (LRMG) is provided by the Commonwealth through the Australian Nuclear Science and Technology Organisation (ANSTO) to assist a nominated State Radiation Officer (SRO)/Territory Radiation Officer (TRO) to ensure monitoring and radiological advice required in OPSMAN 1 and the local Port Safety Plan is provided. The monitoring consists of both the routine radiation monitoring surveillance carried during the NPW visit and additional monitoring carried out in the event of damage to the NPW reactor. A Radiation Monitoring Group (RMG) of 3 or 4 Mobile Monitoring Units (MMU) (depending on the port plan) is provided by the Australian Royal Navy (RAN) and/or State personnel at the port to carry out radiation monitoring under the direction of the LRMG in consultation with the SRO/TRO.

Measurements carried out by the MMUs indicate the levels of radiation exposure the population and emergency response workers may be exposed to. These levels are compared with those at which "Protective Actions" are justified, as detailed in the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Recommendations, Intervention in Emergency Situations Involving Radiation Exposure. Radiation Health Series No 7 (RPS 7) (ref 2) which should be read in conjunction with this Handbook.

2. PURPOSE

The purpose of this monitoring handbook is to provide details for the members of the RMG on the monitoring equipment and procedures to be followed and also provides some technical and background information useful to the LRMG and SRO. The handbook has been written on the assumption that people fulfilling all the above roles have had appropriate radiation safety (health physics) training.

The handbook covers routine monitoring, and the monitoring tasks to be carried out immediately following an accident to the reactor which leads to elevated radiation levels around the vessel and/or a release of airborne radioactive material. This monitoring will also be used to confirm when the release of material has been terminated and/or that the removal of the vessel has removed the airborne radioactive hazard. The monitoring described in this handbook is therefore used to determine the Short Term Protective Actions while the vessel remains in port and shortly after the release is terminated or the vessel has been removed.

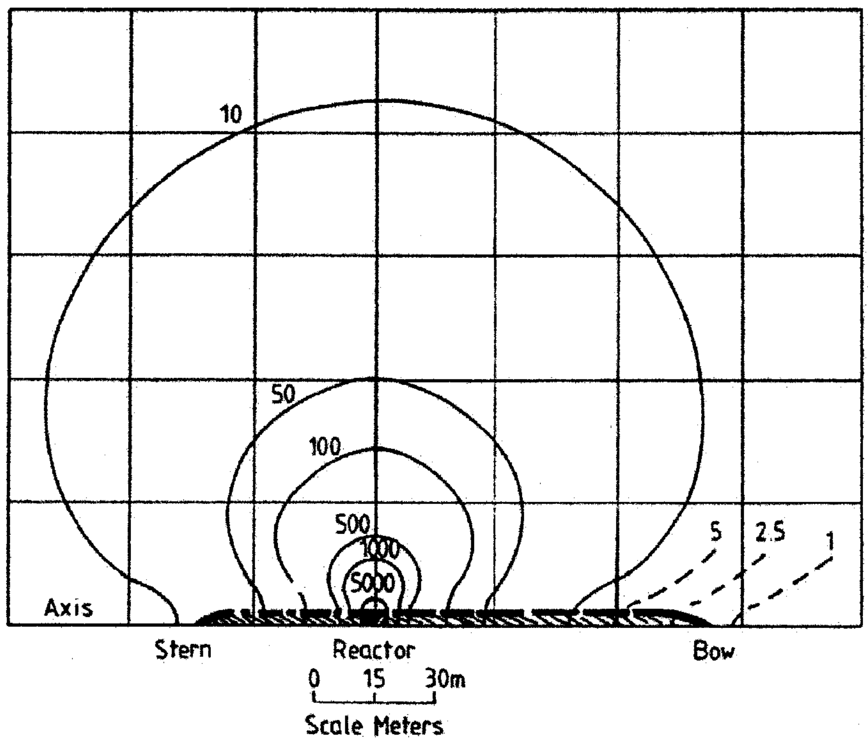
Long term Protective Actions required due to deposited radioactive materials remaining after any radioactive release has been terminated, or the vessel removed, are dealt with in ARPANSA's Technical Report (ref 3). The long term Protective Action may include the ban on consumption of locally produced food stuffs and the relocation of part of the population.

3. BACKGROUND INFORMATION

3.1 Potential Hazards for a Nuclear Reactor Accident

The nuclear reactors that power warships are built to be reliable and have an excellent safety record, however, there is a very slight possibility that the reactor could be damaged. Damage to the reactor may lead to elevated radiation levels in the vicinity of the vessel and/or a release of airborne radioactive material (radioactive plume) which would travel with the prevailing winds. An indication of the elevated external radiation levels around the vessel is shown below.

Figure 1. Expected Gamma Radiation Levels Around a Submarine following a Severe Nuclear Reactor Accident



Characteristic Isodose Contour Chart for Gamma Radiation Dose Rates (mSv/h) in the Horizontal Plane about 1 m above the Hull Surface

ARPANSA have calculated (ref 4) the possible consequences of a severe reactor accident and the Port Safety Plans and the monitoring procedures in this handbook have been written to deal with those consequences.

The radioactive materials released from a severely damaged nuclear reactor would be a mixture of radioactive "fission products" including radio-iodines, radioactive noble gases and radioactive particles such as Caesuim-137. If radioactive material does not escape from the vessel the hazard will only be from the external radiation in the vicinity of the vessel. If the radioactive material escapes from the vessel people down wind will be exposed to the external radiation from the radioactive plume and the intake of radioactive materials. Radioiodines will contribute the major radiation exposure from the intake of the radioactive material ion the plume. Radioiodine contains a number of iodine isotopes, but as Iodine-131 leads to 50% of the thyroid dose and this is used as a marker for all the radioiodines. Both air sample and dose rate measurements are used to confirm the release of radioactive materials and to determine what Protective Actions might be required.

In general, the radioactive hazards from a damaged reactor can be described as follows:

- **cloud shine** - external radiation from airborne fission products;

- **airborne contamination** - with the potential for internal radiation by inhalation of airborne fission products;

- **ground shine** - external radiation from fission products deposited on the ground;

- **ground contamination, water contamination, and uptake in vegetation** with the potential for internal radiation by ingestion of foodstuffs produced in contaminated areas, eg, milk from cows grazing on contaminated areas up to several kilometres downwind could be hazardous, due to the concentration of iodine in cow's milk. This hazard is addressed in another document (ref 3) which deals with the long term protection of people from deposited radioactive materials.

When the release is terminated or if radioiodine is not present, Caesium-137 would be the most hazardous material and dose rate measurements would be used to determine any Protective Actions, particularly from material deposited on the ground and other surfaces.

3.2 Protective Actions

This handbook is intended to address the protection of people from the external radiation in the vicinity of the vessel, cloud shine, airborne contamination and the initial ground shine. The Protective Actions which are used to achieve this are:

- sheltering indoors with doors and windows closed and air conditioning turned off;

- evacuation of areas adjacent to the vessel and in the path of airborne radioactivity; and

- prophylaxis by administration of stable (inactive) iodine to those in the path of the radioactive plume. **(Recommended dose of stable iodine (ref 2) are provided in Appendix 3 for reference.)**

3.3 Emergency Planning Zones

Recommendations in RPS 7 specify that for planning purposes it is convenient to define a series of emergency zones around the NPW, defined by the magnitude of risk and the nature of the response. The emergency planning zones are the Precautionary Action Zone, the Urgent Protective Action Planning Zone and the Long Term Protective Action Planning Zone. A brief description of these zones is given below.

(i) Precautionary Action Zone (PAZ)

The PAZ is a pre-designated area where urgent protective actions have been pre-planned and will be implemented immediately upon declaration of a general emergency. The goal is to substantially reduce the risk of deterministic health (high dose) effects by taking protective action *before* a release.

For an NPW the PAZ is a region close to the NPW where people may be exposed to direct gamma shine from the vessel, as well as airborne radioactive material following an accident. The extent of the PAZ is defined as the maximum distance to which immediate evacuation would be required.

- For submarines and smaller surface vessels the PAZ is a circle of radius of 600 m centred on the vessel.
- For NIMITZ class aircraft carriers the PAZ is a circle of radius 800 m centred on the vessel.

The PAZ corresponds to Zone 1 previously used in NPW plans and now replaces that term.

(ii) Urgent Protective Action Planning Zone (UPZ)

The UPZ is a pre-designated area around an NPW where preparations are made to promptly implement urgent protective actions based on environmental monitoring. The UPZ represents an area within which the possible radiation doses people might receive do not justify evacuation, but where sheltering and/or the issue of stable iodine may be justified.

- For submarines and smaller surface vessels, with a vessel removal time of 24 hours, the UPZ is any 30 degree downwind sector within a circle of radius 2.8 km.
- For submarines and smaller surface vessels, with a vessel removal time of 4 hours, the UPZ is any 30 degree downwind sector within a circle of radius 2.3 km.
- For NIMITZ class aircraft carriers, with a vessel removal time of 2 hours, the UPZ is a 30 degree downwind sector within a circle of radius 3.7 km.

The UPZ corresponds to the area previously known as Zone 2 and now replaces that term.

(iii) Long Term Protective Action Planning Zone (LPZ)

The LPZ represents an area within which the surrounding population may be subject to hazards associated with long term exposure to ground deposited radioactive material (ground shine), and ingestion of contaminated water, foodstuffs, milk and agricultural produce. Due to the slow rate of accrual of ground shine and ingestion doses, immediate action is not required to protect the population from these hazards. Decisions to implement protective actions, such as relocation and food restrictions, would be made based on the results of extensive radiation and contamination monitoring which are described in ref 4.

The LPZ may incorporate the PAZ, the UPZ and extend beyond these areas, this corresponds to the area previously known as Zone 3 and now replaces that term.

4. RADIATION PROTECTION STANDARDS

RPS 7 details exposure levels at which actions should be taken; this also incudes dose limits for the emergency responders, including the members of the MMUs.

4.1 Emergency Worker Guidance Levels

Table 1 provides Dose Guidance for Emergency Workers consistent with RPS 7 with additional guidance based on Appendix 3 to IAEA EPR Method 2003 - Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency, and is reproduced below.

Table 1
Emergency Worker Dose Guidance Levels

Tasks	Level [mSv]
Life saving actions, such as: 1. rescue from immediate threats to life; and 2. prevention or mitigation of conditions resulting in an emergency where there is a potential or actual release of radioactive material from a reactor which requires urgent protective actions.	> 500[(1)]
Type 1: **Potential life saving actions, such as:** 1. implementation of urgent protective actions at the site of the nuclear reactor; 2. prevention or mitigation of conditions (eg fires) that potentially endanger lives; 3. environmental monitoring of populated areas in the emergency zones to identify where urgent protective actions are needed; and 4. implementation of urgent protective actions off the site of the nuclear reactor. **Actions to prevent the development of catastrophic conditions, such as** prevention or mitigation of conditions resulting in an alert or emergency where there is a potential or actual release of radioactive material from a reactor which requires urgent protective actions.	< 500
Type 2: **Actions to prevent serious injury, such as:** 1. rescue from potential threats of serious injury; 2. immediate treatment of serious injuries; and 3. decontamination of people. **Actions to avert a large collective dose, such as:** 1. environmental monitoring of populated areas to identify where protective actions or food restrictions may be needed; and 2. implementation of protective actions and food restrictions off site.	< 100
Type 3: **Other emergency phase intervention, such as:** 1. longer term treatment of exposed and contaminated individuals; 2. sample collection and analysis; 3. short term recovery operations; 4. localized decontamination; and 5. keeping the public informed.	< 50
Type 4: **Recovery operations, such as:** 1. repairs to the facility not related to safety; 2. large scale decontamination; 3. waste disposal; and 4. long term medical management.	Occupational exposure guidance (50 mSv in a single year)

[(1)]This level assumes the action is justified and deterministic effects are prevented.

4.2 Generic Intervention Levels for Protective Actions

Generic Intervention Levels (GIL) are guidance values for the implementation of protective measures. They are specified in terms of the radiation dose that can be averted (avoided) by the protective measure. The Australian recommendation in RPS 7 provides values for Protective Action to be taken during the incident and also those for the longer term. As this handbook only covers the incident until the vessel has been removed and/or the airborne discharge has been terminated, (ie, the immediate incident) only the GILs for that period are shown below.

Table 2
Recommended Generic Intervention Levels for Protective Measures for the General Public

Protective action	Generic intervention level*
Urgent protective measures	
Sheltering	10mSv
Evacuation	50mSv
Iodine prophylaxis	100 mGy for adults 30 mGy for Children

*All values are **avertable doses**

Avertable dose is the term used to express the dose that may be saved by the implementation of a protective action. The decision to use a particular protective measure should be based on an estimate of the averted dose and the use of Generic Intervention Levels.

During an emergency it will not be possible to accurately estimate the time to implement protective actions, the remaining potential exposure and hence the avertable dose. The pre-calculated **projected dose** over the vessels removal time will be used in this handbook as a conservative trigger for the implementation of protective measures, however, State/Territory Health Representatives may decide not to implement protective actions if they feel the avertable dose does not justify the action.

GILs are specified in terms of the potential dose to an individual and cannot be measured directly, and are estimated from the measured radiation and the exposure pathways. Alternatively, by assuming, as part of the planning process, typical exposure scenarios then the avertable dose can be related to field measurements such as ambient dose rate from the plume or from deposition and marker radionuclide concentration in the plume. These measurable levels are called Operational Intervention Levels (OILs). RPS 7 recommends OILs based on a 4 hour exposure period for different situations. OILs 1 to 2C and I-131 in the plume are relevant to this handbook and these OILs are been quoted in Table 3 below.

Table 3
Operational Intervention Levels in a Reactor Accident for a 4 hour Vessel Removal/Exposure Period

Basis	OIL	Default value	Protective measure
Ambient dose rate	OIL1	1 mSv h^{-1}(a)	Evacuation
	OIL2	100 μSv h^{-1}(b)	Sheltering
	OIL2	100 μSv h^{-1}	Iodine Prophylaxis Adult
	OIL2c	20 μSv h^{-1}	Iodine Prophylaxis Child
Marker radionuclide concentration in plume: I-131 Based on I-131 delivering 50% of thyroid dose from inhaled airborne radioactivity in plume.		50 kBq m^{-3}	Iodine Prophylaxis Adult
		10 kBq m^{-3}	Iodine Prophylaxis Child

(a) If there is no indication of core damage or radioiodine is not present in the plume, then there is no inhalation dose and OIL1 = 10 mSv h^{-1}.(+)

(b) If there is no indication of core damage or radioiodine is not present in the plume, then there is no inhalation dose and OIL2 = 1 mSv h^{-1}.(+)

4.2.1 Operational Intervention Levels to be used at the start of the incident and while releases to the environment are continuing

The OILs used in this hand book are those appropriate for the start of the incident and while releases to the environment are continuing. When the field team data has been received and processed by the LRMG and SRO/TRO these results will be plotted on a "situation" map. To more easily identify the areas where immediate Protective Actions are required the results will be colour coded based on the OILs as shown in Table 4 in section 7.2.

The OILs in table 3 are for vessel removal/exposures over 4 hours. Removal times, and hence exposure times, for NPW submarines and aircraft carriers in Australian Ports may be different to 4 hours. The OILs 1 to 2C and the iodine-131 marker in the plume have therefore been calculated for various times and these values are quoted in Table 4 in section 7.2 in terms of the colour code for the appropriate Protective Action justified by the OIL. These protective actions, along with their colour codes are shown in Table 5.

It should be noted that around Australian ports it has been found that prevailing winds come from the same direction for no more than 12 hours. For a vessel with a 24 hour removal time 12 hours is therefore used for the projected dose.

5. MONITORING PROCEDURES

5.1 Fixed Early Warning System (EWS)

To provide a warning of any build up of radioactive material in the vessel, indicating a release of radioactive material from a damaged reactor, the LRMG will ensure the radiation monitoring Early Warning System (EWS) is positioned in the vicinity of the vessel and manned continually for the duration of the visit, with someone in a position to hear any alarm activation at all times.

Early Warning System

The EWS system incorporates 3 low-range Geiger Muller (gm) tubes covering a dose rate range from 0.01 μSv/h to 100 μSv/h and a high-range Geiger Muller tube covering a dose rate range of 100 μSv/h to 100 mSv/h.

Signals from each of the detectors are fed to a receiver/alarm and a lap top chart recorder at the monitoring post. The system is set to alarm at 1 μSv/h.

The early warning detectors should be set up in a direct line of sight with the NPW and should be located no closer than 50 metres (US Navy restriction) and no further than 600 metres from the vessel.

When the fixed early warning system (EWS) is switched on for the first time prior to the NPWs visit, the system should be in position and operated for 12 to 24 hours prior to the arrival of the vessel. This procedure will establish reliable background radiation measurements and determine that the equipment is functioning as expected.

The operating settings (eg, load, supply etc) of the early warning equipment should be checked at least daily and a record of the results kept. At the time of these checks a dose rate measurement should be carried out and the result recorded. In addition, a daily alarm function check should be carried out using a small radioactive source of sufficient activity to activate the set alarm.

5.1.1 Action to be taken in the event of an EWS alarm

In the event of the alarm on the EWS activating, the person monitoring the system must carry out the notifications specified in the Port Visit Instruction/Visit Operations Order. The procedure for the notification of the LRMG, SRO/TRO, MMUs and other responders will then be carried out and they will follow their pre-planned actions.

The confirmation of the alarm should then be carried out either by discussions with the vessel Captain/Representative, the LRMG confirming the alarm (by examining the EWS, by directly measuring the dose rate close to the vessel or requesting the PAZ Duty Officer to do this). On confirmation of the alarm the LRMG will provide instructions for the field teams to start carrying out radiation monitoring at locations in the UPZ, and possibly beyond, as determined by wind direction and population.

5.2 Action to be Taken by LRMG After Confirmation of the Alarm

5.2.1 Follow the response instruction detailed in the specific Port Plan and visit instruction. An important piece of information which must be obtained is the wind speed and direction, these will determine monitoring locations.

5.2.2 Working in consultation with the SRO/TRO direct the MMU field teams to carry out radiation measurements in the UPZ down wind from the vessel to determine the extent and magnitude of any radioactive release, and to ensure prompt action is taken to protect the public.

5.2.3 Unless otherwise stated in the Port Plan or visit instructions, notify the MMUs to take one stable iodine tablet.

5.2.4 In conjunction with the SRO/TRO determine suitable locations on the map where measurements should be taken. These should be based on wind speed and direction, and populated areas (particularly of "vulnerable groups" such as schools and hospitals).

5.2.5 Provide the monitoring location in terms of a map number and alpha numeric grid coordinates (or other locally agreed method) to the communications officer for transmission to the MMUs.

5.2.6 When an MMU reports their results, ensure the MONREP data is checked and the air concentration calculated.

5.2.7 Compare the air concentration and reported dose rates with the colour code table for the appropriate Protective Actions and determine the colour of the marker to be plotted on the "situation map". Ensure the marker is plotted on the map.

5.2.8 Advise the SRO/TRO whether the results of field measurements require Protective Actions to be considered.

5.2.9 Determine the location of the next field measurement and have the radio operator transmit this to the appropriate MMU.

5.2.10 At regular intervals inform the MMUs of the overall situation, eg, change of wind direction, vessel removal etc. Also ask the MMUs to report their electronic dosimeter reading and ensure they are not likely to exceed dose limits.

5.2.11 If necessary, owing to the MMUs radiation exposure or the duration of the monitoring operation, determine whether teams need to be replaced.

5.2.12 Continue the monitoring operation until the MMU measurements and vessel situation indicate the incident is over and the Emergency Controller terminates the response.

5.3 Action to be Taken by SRO/TRO After Confirmation of the Alarm

5.3.1 Follow the response instruction detailed in the specific Port Plan and visit instruction.

5.3.2 Discuss the deployment of the MMUs with the LRMG.

5.3.3 In conjunction with the LRMG instruct the MMUs where to carry out monitoring and compare the results with the levels at which Protective Actions should be implemented.

5.3.4 On the basis of data received from the vessel and information from the LRMG on the results of radiological monitoring, advise the Emergency Controller on:

- hazards to the health of members of the public,
- the need to implement Protective Actions, and
- when normal activities may be resumed in affected areas.

5.3.5 Advise the Emergency Controller when monitoring data indicates the immediate incident is over.

5.4 Actions to be Taken by the MMU

5.4.1 On notification of an EWS alarm the members of the MMU must follow the procedures detailed in the Port Visit Instruction/Visit Operations Order.

5.4.2 Switch on the battery operated monitoring equipment in the field kits and check they are working. If any unit is not working replace the battery or contact the LRMG or Navy Technician to arrange a replacement unit.

5.4.3 Take one of the TLDs in the field kits and fix to clothing at chest level with the TLD's logo facing outwards. Complete the TLD issue form in the kit. (If protective clothing is worn fix the TLD beneath the outer layer of clothing.)

5.4.4 Switch on one of the electronic dosimeters in the field kit and place this on the clothing with the blue label on the meter facing the body. If the dosimeter is not reading zero make a note of the value and inform the LRMG.

5.4.5 If not already received, request information from the LRMG regarding taking one of the stable iodine tablets in the field kit.

5.4.6 If instructions have not been received regarding the location where monitoring is to be carried out contact the emergency operations centre (EOC) and request instructions.

5.4.7 With the equipment switched on, move to the location where the monitoring is to be carried out. If the NaI detector indicates a high point while on the way to the location note the position and report this to the EOC.

5.4.8 On arrival at the monitoring location carry out the following in the order you find best:

- take an air sample,
- monitor the air sample cartridge using the NaI detector,
- carry out dose rate measurements in the vehicle and 10 m away,
- measure the wind speed and direction,
- measure the GPS position of the monitoring location.

(Specific instructions on the use of the equipment are given in section 6.)

5.4.9 Enter the results on a MONREP form.

5.4.10 Send the MONREP results to the EOC using the communication method provided.

5.4.11 Leave the monitors switched on and report any significant changes.

5.4.12 Wait for instructions regarding a new location to carry out monitoring. If no instruction has been received after 10 minutes of sending the MONREP contact the EOC and tell them you are waiting for a new location.

5.4.13 When instructed that the emergency is over and you have finished monitoring, ensure the TLD you have worn is returned to the LRMG for processing at ANSTO.

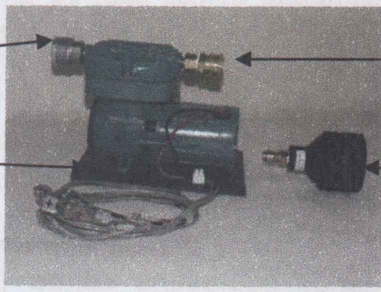
6. OPERATION OF MONITORING EQUIPMENT

6.1 Operation of Air-Sampler Incorporating HI-Q RVH-20 Filter Cartridge Holder

6.1.1 Remove the battery operated air-sampler and the cartridge holder from the equipment boxes.

6.1.2 Connect the RVH-20 holder to the sample pump as follows:

- Push the brass retaining collar on the "snap-lock" fitting as far as it will go towards the body of the pump. (The ball bearings in the fitting will become visible.)



- Hold the collar in place and push the brass tube of the RVH-20 holder as far as it will go into the "snap-lock" fitting.

- Release the brass collar. (This should "spring" away from the body of the pump and cover the ball bearings.) Push and twist the holder into the fitting to ensure a good fit.

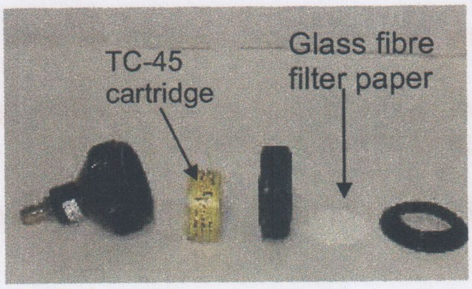
Pump with RVH-20 holder connected

6.1.3 Loading a new sample cartridge and glass fibre filter as follows:

- Hold the cartridge holder, unscrew (anti-clockwise) and remove the thin filter retaining ring.

- Unscrew and remove the large cartridge retaining ring. (Note that the cartridge retaining ring has a smaller diameter on one side to hold the filter retaining ring.)

- Take a glass fibre filter paper from the box in the equipment kit, and with the smaller diameter of the cartridge retaining ring facing upwards, place the filter paper in the depression over the "honeycomb" grill. (Note: Some filters have a smooth and a rough side. If this is the case, the rough side should face away from the cartridge retaining ring.)



- Screw the thin retaining ring into the cartridge retaining ring, "finger tight", to hold the filter. Ensure that the grill is not visible (this would allow air to by-pass the filter) - if it is, reposition the filter in place.

- Gently mark a dot at the edge of the filter paper with a marker pen to indicate which side will trap material. <u>NOTE: DO NOT PUNCH A HOLE IN THE FILTER!</u>

- Place the assembled retaining rings in a "safe" place where the filter will not get dirty or wet.

- Take a TC-45 cartridge from the equipment box, and with the arrow on the cartridge pointing towards the pump, place it as far as it will go into the cartridge holder cavity.

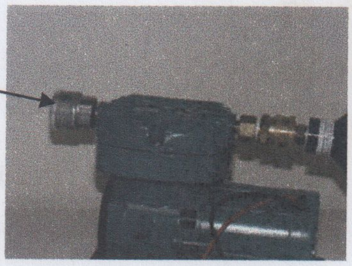
- Take the retaining ring assembly and screw it into place, "finger tight", to hold the cartridge.

- The pump and sample head is now ready to be used to carry out air-samples.

6.1.4 Position the pump with RVH-20 holder at least 0.5 m above ground level with the holder facing into the wind. However, if it is raining reposition the pump so that the filter in the holder is facing away from the rain so it does not get wet.

6.1.5 Ensure the exhaust filter is fixed in position. (The airflow rate will not be correct without this filter.)

Exhaust filter



6.1.6 The pump is powered by a 12V DC supply and although this is usually connected to the car battery, a separate battery unit may be provided so the sampler can be moved away from the car.

- The pumps electrical leads to connect to the 12 V supply will either be a car “cigarette lighter plug” or “crocodile clips”.
- The cigarette lighter adaptor connects into the car’s adaptor or battery pack. When using the “crocodile clips” it must be ensured that once one clip is connected to the battery the other one does not “short” on the body of the car.

6.1.7 Write on the MONREP the time the pump was started.

6.1.8 When the pump has been running for 5 minutes, (or the time specified in the radio instructions) disconnect the pump from the electrical supply.

6.1.9 Take two plastic bags from the equipment kit. Write the following details on each bag:

- Date,
- Field team number,
- Location where air-sample taken,
- Time air-sample started,
- Sampling/pump running time (normally 5 minutes).

6.1.10 Put on disposable gloves.

6.1.11 Unscrew the filter paper and sample cartridge retaining ring assembly and place it somewhere safe, facing filter side up away from dirt and water.

6.1.12 Remove the sample cartridge and place it in one of the labelled plastic bags.

6.1.13 Take the filter paper and sample cartridge retaining ring assembly and with the filter facing upwards unscrew and remove the filter paper retaining ring.

6.1.14 Place a clean filter paper on top of the used filter paper to prevent loss of sampled material.

6.1.15 Open the remaining labelled plastic bag, and place the filter side of the holder above the open bag.

6.1.16 From the back of the "honeycomb" grill, using the thin prongs of the forceps found in the kit, **GENTLY** push both the filters away from the other side of the grill. Place the filters in the plastic bag. NOTE: IT IS IMPORTANT NOT TO DAMAGE THE GRILL OR TO TEAR THE FILTER!

6.1.17 Remove the disposable gloves and store for later disposal.

6.1.18 Depending on whether more sampling is to be carried out, the sample head assembly can now be re-assembled either with or without filters and cartridges in place.

6.1.19 When sampling is finished and the filter holder is to be removed, push the brass retaining collar on the "snap-lock" fitting as far as it will go towards the body of the pump. (The ball bearings in the fitting will become visible.)

6.1.20 Hold the collar in place and pull and twist the RVH-20 holder out of the collar.

6.1.21 Release the brass collar. (This should "spring" away from the body of the pump and cover the ball bearings.)

6.1.22 Return the pump and the holder to the storage boxes.

6.2 Use of NaI Detector and ASP 2 Rate Meter

The sodium iodide detector is sensitive to gamma radiation and is used to monitor the radioiodine in TC-45 air sample cartridges. It can also be used to measure "cloud" and "ground" shine and gamma contamination. The ASP 2 and ASP 2(e) rate meters provide a digital and analogue display of the count rate measured by the NaI detector.

The use of the ASP 2 and 2 (e) dealt with in this manual is similar and although the rate meters look slightly different the ASP 2 has been used to describe the use of both.

NaI Detector and ASP 2 Rate Meter

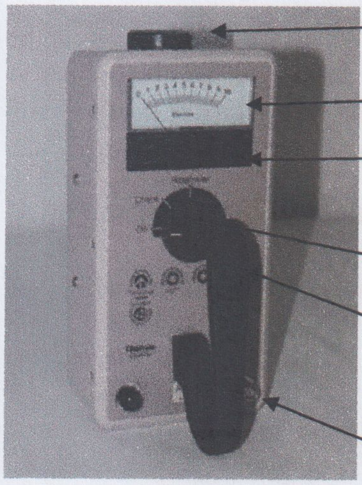
6.2.1 Ensure the rate meter is switched off and connect the NaI probe to the rate meter using the cable provided. (This cable has two different types of connector and can only be connected one way.)

6.2.2 Switch the rotary “On/Off switch” to the “Check” position and wait about 10 seconds before rotating the switch to the “Rate meter” position. The unit is now ready to use.

6.2.3 Record the background count rate.

6.2.4 To monitor a TC-45 air sample cartridge, place the cartridge (inside the plastic bag) against the front of the NaI detector with the arrow on the cartridge pointing away from the detector.

6.2.5. The count rate will fluctuate and an estimate of the average reading should be recorded on the MONREP form.



6.2.6 Keep the monitor switched on with the 'speaker' operating when moving to a new location. If an increase in count rate is heard, stop and check the reading. When a second person is in the vehicle they can watch the display. Any significant change in readings/count rate (use double the background as a guide) should be reported to the EOC.

6.2.7 When monitoring contamination, in the air and on surfaces, push the loud speaker button so that the increase in reading can be heard at “high points”. When carrying out **surface contamination measurements** point the front of the probe towards the surface and keep it about 0.5 cm above it. Move the probe slowly over the surface and record the readings. If an increase in the count rate is heard, move the probe back to that position and look at the reading on the display.

6.3 Changing Batteries in the ASP 2

6.3.1 Switch the rate meter off.

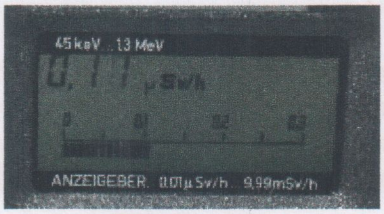
6.3.2 Unscrew the black cap on the battery compartment.

6.3.3 Replace the batteries with new ones and ensure the batteries are the correct way around as indicated by the “polarity” sign on the cap.

6.4 Carrying Out Dose Rate Measurements Using the Thermo FH 40F1 and FH 40F2 Dose Rate Monitors

These dose rate monitors both incorporate internal energy compensated geiger-Muller (gm) tubes which, when calibrated, are suitable to monitor the gamma ray emissions from the radioactive materials potentially present following a reactor incident.

The measured dose rate is indicated on the liquid crystal display (LCD) as both a digital value or as a moving bar. The LCD display is self ranging and in the dose rate mode will display either μSv h^{-1} or mSv h^{-1}. **NOTE: The μ and m on the display are about 3 mm high and are easy to miss! You must check which unit is being displayed - mSv h^{-1} is 1000 times larger than μSv h^{-1}!**



<u>**LCD display**</u>

The only difference in these two models of instrument is their measurement ranges. The FH 40F1 has a range from 3 μSv h^{-1} to 999 mSv h^{-1}, while the FH 40F2 has a range from 0.01 μSv h^{-1} to 9.99 mSv h^{-1}. **Unless instructed otherwise, carry out dose rate measurements using the FH 40F2 and connect the FHZ 731 contamination probe to the FH 40F1 if required (see the end section 6.7).**

Both units also incorporate a dose rate and accumulated dose alarms as well as an indication of the accumulated dose since it was last re-set. Under normal conditions the dose rate alarm will have been set at 250 μSv h^{-1} and the accumulated dose at 1 mSv.

6.4.1 Switch on the dose rate monitor by pressing button 1 until the unit "beeps", then release the button.

6.4.2 Wait for the unit to perform its operational check. This check includes a battery check, if the battery symbol continues to flash at any time, change the battery as indicated in section 6.8.

6.4.3 When the display indicates the dose rate wait about 90 s before starting to take dose rate measurements.

6.4.4 When the direction of the radiation source is known point the yellow triangle towards it. If the direction is not known, point the monitor in a different direction to obtain the highest value.

6.4.5 The dose rate indication will fluctuate, record the approximate average reading on the MONREP form.

6.4.6 If it is dark and the display is difficult to read switch on the display “back light” by pushing button 2. When not required switch off the back light by pressing button 2 again.

6.4.7 If required the monitor’s loud speaker can be switched on by pressing button 3. Press the button again to switch the loud speaker off. (The use of the loud speaker is the operator’s choice.)

6.4.8 Keep the dose rate monitor switched on when moving to a new monitoring location. Where the field team consists of two people the one not driving should check if the dose rate suddenly increases in value. (This may indicate the centre line of any plume and should be reported to the control centre.)

6.4.9 Where only one person is in the team they should not be watching the display while driving, however the dose rate alarm will automatically sound if the dose rate exceeds 250 μSv h^{-1} or the accumulated dose exceeds 1 mSv. (Any alarms should be reported to the control centre.) The audible dose rate alarm can be muted by pressing button 3, however the flashing warning symbol will remain until the dose rate drops back below the alarm setting.

6.5 Resetting the Accumulated Dose Reading and Setting the Alarms on the FH 40F1 and FH 40F2 monitors

6.5.1 The accumulated dose reading or any alarms should only be set or re-set by, or under the instruction of, the LRMG or SRO/TRO.

6.5.2 Prior to the field kits being issued, the LRMG should re-set the accumulated dose value to zero and check that the dose rate and accumulated dose alarms are set at 250 μSv h^{-1} and 1 mSv respectively.

6.5.3 To **reset the accumulated dose reading to zero**, with the monitor switched off, press button 2 and hold it down. Switch on the unit by pressing button 1.

6.5.4 Keep button 2 depressed until the accumulated dose value appears, release button 2.

6.5.5 If necessary record the accumulated dose and the name/s of the operators.

6.5.6 Re-set the accumulated dose to zero by pressing button 2 a second time. The display should return to dose rate mode if this does not happen press button 2 again.

6.5.7 **To reset dose rate and accumulated dose alarms,** with the monitor switched off, press button 3 and keep held down. Switch on the monitor by pressing button 1.

6.5.8 When the present dose rate alarm level appears release button 3.

6.5.9 If the **dose rate alarm** is not to be changed continue as described in 6.5.10. If the setting is to be changed repeatedly press button 3 until the required dose rate alarm is reached.

6.5.10 Press button 2. **The accumulated dose alarm will now be displayed**.

6.5.11 If the accumulated dose is not to be changed press button 2.

6.5.12 **To change the accumulated dose alarm** press button 3 repeatedly until the desired value is reached then press button 2.

6.6 Viewing the Accumulated Dose and Dose Rate Alarm on the FH 40F1 and FH 40F2 Monitors while Carrying out Dose Rate Measurements

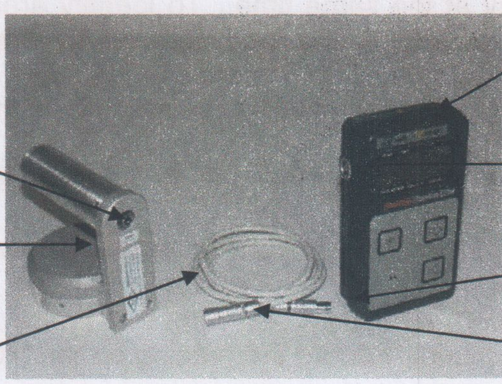
6.6.1 To **view the accumulated dose,** with the monitor switched on, press and hold button2. The accumulated dose will be displayed. This value is the dose the monitor has received but should be similar to the value shown on the electronic dosimeter you will be wearing.

6.6.2 To return to the measurement mode release button 2.

6.6.3 To **view the dose rate alarm,** with the monitor switched on, press and hold button 3. Under normal monitoring operations this will be set at 250 μSv h^{-1} but may be altered by, or under the instruction from, the LRMG or SRO/TRO for special operations.

6.7 Use of the FHZ 731 Pancake Probe with the FH 40F1 and FH 40F2

This probe contains an "end window" gm tube used for carrying out contamination measurements and can be used to check air sample cartridges if the NaI detector is not working.



__FHZ 731 Pancake Probe and Dose Rate Monitor__

6.7.1 Where available use the pancake probe connected to an FH 40F1 dose rate monitor, however the FH 40F2 can also be used.

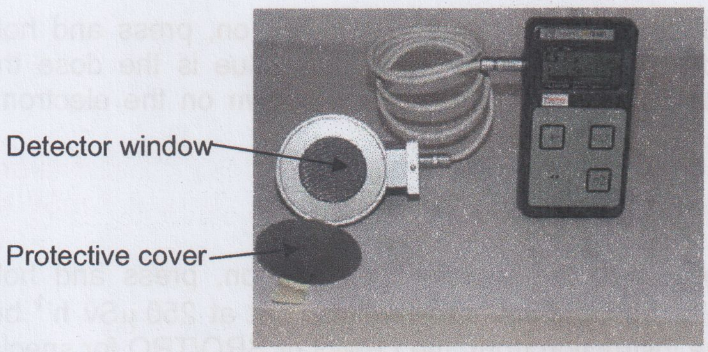
6.7.2 With the dose rate monitor switch off, connect the probe to the monitor with the connection cable. The FP connector goes onto the pancake probe socket and the MP connector goes into the dose rate monitor socket.

6.7.3 The cable connector and instrument sockets have a semi circular metal guide to ensure the cable pins are in the correct position. If the connector does not go into the socket rotate the connector until the guides line up.

6.7.4 Switch on the monitor by pressing and then releasing button 1 (see previous section).

6.7.5 The display will indicate units a **S^{-1}** (per second) and β **EXT** will appear in the right side of the display.

6.7.6 Unless otherwise instructed the protective cover on the bottom of the gm tube should be removed/open from the detector window before measurements are carried out.



6.7.7 The count rate indication on the display will fluctuate and the approximate average reading for any measurement should be the one recorded.

6.7.8 If requested to carry out a **contamination measurement on people or surfaces** the pancake probe should be held with the probe window pointing towards the surface and about 0.5 cm above it. Move the probe slowly over the surface and record the readings. You will need to watch the position of the probe and it is difficult to watch the display at the same time. To identify areas of contamination you may find it helpful to switch on the loud speaker by pressing button 3 and listening for increases in count rate. If an increase in the count rate is heard, move the probe back to that position and then look at the reading on the display.

6.7.9 **If an air sample cartridge is to be monitored** carry out the following steps:

- ensure the protective cover of the detector is removed/open,
- carry out a background measurement with the probe at waist level and pointing towards the ground. Record the reading on the MONREP form,
- place the air sample cartridge in its plastic bag against the centre of probe window with the arrow on the cartridge pointing away from the probe. Record the reading on the MONREP form. **NOTE: The plastic bag is to prevent the possible spread of contamination and will not significantly reduce the instrument reading.**

6.7.10 When the probe is not being used the protective cover should be placed over the probe window.

6.7.11 When all measurements with the pancake probe have been completed the monitor can be switched off by pressing button 1. The connecting cable can then be removed by pulling the connectors out of the sockets.

6.8 Replacing the Batteries in FH 40F1 and FH 40F2 Dose Rate Monitors

6.8.1 When the battery symbol in the top right hand corner of the monitor display flashes the battery needs to be changed.

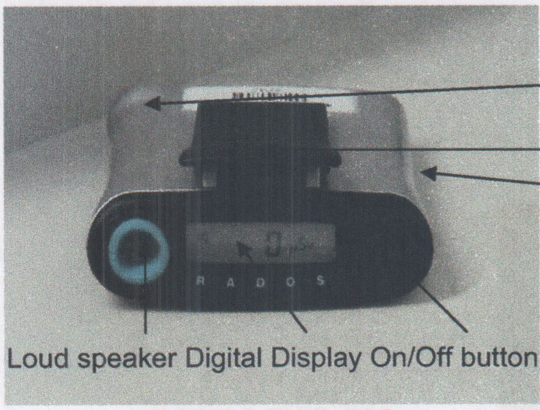
6.8.2 Switch the monitor off by pressing button 1.

6.8.3 Use a coin, or a screwdriver from the monitoring kit, to release the large screw holding the battery cover at the bottom and rear of the monitor.

6.8.4 Remove the 9 V battery and replace it with a new one from the monitoring kit.

6.9 Use of Electronic Dosimeter RADOS RAD 60S

The RAS 60S has a digital display to indicate the accumulated dose and the dose rate and has an audible alarm. The alarms will be set by the LRMG at 1 mSv and 1 mSv h^{-1} respectively.



RADOS RAD 60S

6.9.1 Switch on the electronic dosimeter by pressing the black button until it “bleeps” and then release the button.

6.9.2 Place the dosimeter on the clothing with the blue label towards the body.

6.9.3 If the dosimeter is not reading zero make a note of the value and inform the LRMG.

6.9.4 Regularly look at the LCD display, if the reading reaches 100 s of μSv notify the LRMG.

6.9.5 If the audible alarm activates notify the LRMG.

6.10 Changing the Battery in the RAD 60S

6.10.1 Use screwdriver or a coin to unscrew the battery compartment cap underneath the unit.

6.10.2 Replace the battery and ensure it is placed in the compartment the correct way around as indicated by the diagram/polarity sign.

6.11 Maps and Global Positioning Systems

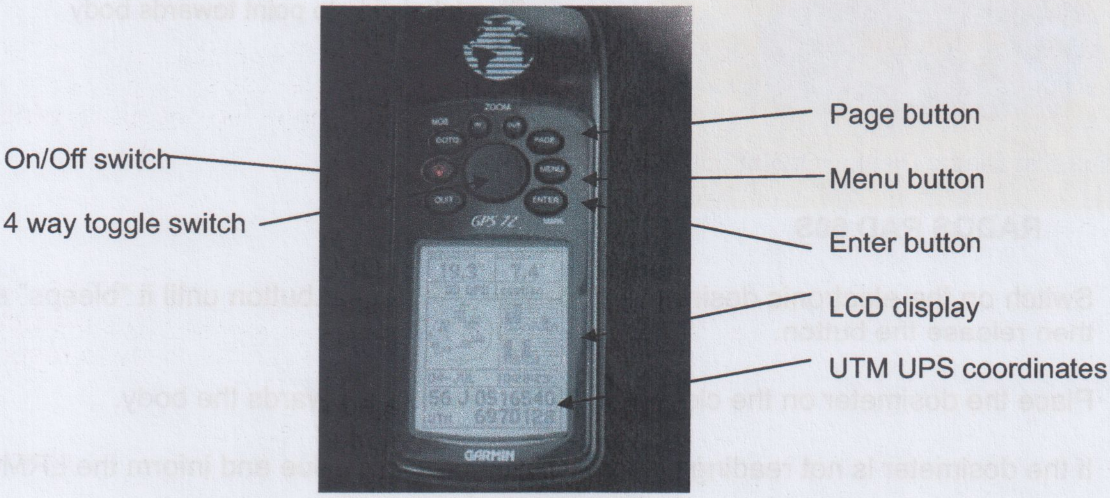
MMUs will be issued with UBD, Streetsmart or other local maps to allow them to move to monitoring locations and enable the results to be plotted on the main map in the Emergency Operations Centre (EOC).

Sampling site locations can be specified by description (eg junction of road X with road Y) or by use of the map or street directory grid references (eg, map 330, L 3). An identical full size map is required at the EOC to assist in directing mobile monitoring teams and in plotting data provided by the teams.

It is an advantage that, where possible, pre-designated monitoring location based on different wind directions are identified and provided to the MMUs. When activated the MMUs can then automatically go to these points and start monitoring.

Land based field teams will also be issued with GPS, but will not be directed to locations using this system. The GPS is only to report the monitoring location. UBD, Streetsmart and other common maps use the GPS UTM UPS grid and Australian Geodetic Datum of 1966 (AGD66). The GPS in the kit will be set to this grid and datum, or another corresponding to different local maps. If monitoring on water, the vessel may be directed using bearings from fixed buoys marked on charts, or the grid and datum of the chart. For waterborne monitoring ask the crew for a location from the vessel's GPS system.

6.12 Operation of Garmin GPS 72



6.12.1 Switch the unit on by pressing the on/off button marked with the red "light bulb" icon.

6.12.2 The first message that comes on the screen is a warning regarding data. Accept this by pressing the enter button.

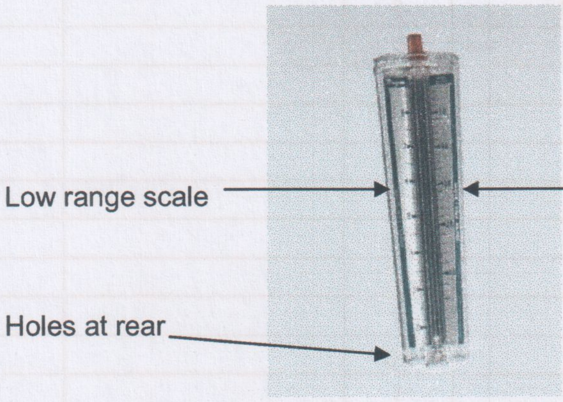
6.12.3 Stand in the open "out doors" and hold the GPS vertically (pointing to the sky) while the GPS searches for satellites. Acquiring sufficient signals may take a few minutes.

6.12.4 When the GPS start to operate if the screen shown above (location coordinates) is not displayed, press the page button until it appears.

6.12.5 After carrying out measurements record the GPS location on the MONREP, write down all the letters and figures.

6.13 Wind Speed and Direction

6.13.1 To determine the wind speed, point the wind meter so that the two holes at the bottom and rear face into the wind.



6.13.2 Note the position of the "floating" ball against the low speed scale on the device.

6.13.3 If the ball is at the top of the tube put your finger over the top of the red tube and note the position of the ball against the high speed scale on the device.

6.13.4 Write the wind speed on the MONREP form.

6.13.5 Use the compass in the kit to determine the approximate direction the wind is coming <u>from</u>. Record the direction in degrees on the MONREP form.

6.14 Field Monitoring Kits

Field monitoring instruments will be sent to the port in a number of transport boxes. One set of boxes containing air sample, radiation measuring equipment and personal protective equipment will be issued to each MMU for them to keep in their vehicles ready to respond to an incident.

A total inventory of the equipment is provided below. This inventory should be checked and the form signed when the kit is issued prior to the start of a vessel visit.

Figure 2. NPW Emergency Monitoring Kit Inventory Check List

Item	Qty	Serial No	Checked
Adhesive Labels for air sample bags	20		
Ball point pens	2		
Compass	1		
Cotton Gloves (pair)	2		
Disposable Gloves (pack)	1		
Disposable Tyvek Suit	4		
Electronic Dosimeter RADOS RDS 60	2		
Felt tip pen	2		
Flat Screwdriver (medium size)	1		
Forceps	1		
Garmin GPS 72	1		
Inventory Forms	5		
KIO_3 tablets	20		
Long Nosed Pliers	1		
Masking Tape (Roll)	1		
MONREP Forms	20		
Notebook	1		
Overshoes (Pair)	2		
Philips Screwdriver (medium size)	1		
Respirator	2		
Respirator Cartridges (I-131 Type)	4		
Rubber Gloves (pair)	2		
RVH -20 cartridge Holder & Attachments	1		
Sealed Plastic Bags for Air Samples	30		
Spare Batteries (9 volts)	2		
Spare Batteries (AA)	2		
Spare Batteries (AAA)	2		
Spare Batteries (C size)	3		
Spare Batteries (D size)	2		
TC-45 cartridges	20		
Thermo Instruments ASP 2/(e)	1		
Thermo Instruments NaI probe	1		
Thermo Instrument FAG FH 40 F1	1		
Thermo Instrument FAG FH 40 F2	1		
Thermo Instrument pancake probe FHZ 731	1		
Thomas Pump	1		
TLD Badges	2		
Torch	1		
Wind Speed Meter	1		

Comments: ....

....

....

Signed: .... Date: ....

6.15 Use of Full Face Respirators, Protective Suits, Gloves and Overshoes

The respirators in the emergency kit have canisters containing activated charcoal and a particulate filter which will remove radioactive iodines and particulate radioactive material. Respirators should be used within PAZ, and elsewhere, when there may be significant levels of airborne contamination.

The protection factor for full face respirators is mainly dependent on any leakage of air between the face and the face mask. The protection factor reduces from about 1000 for clean shaven faces to less than 100 for bearded faces.

The face mask should be tightly fitted to the face. This may be checked by obstructing the intake hole at the base of the canister and drawing breath. A tight fit and leak free fittings will cause a high resistance to drawing breath.

As a precautionary measure protective clothing such as disposable plastic suits, overshoes and cotton gloves should also be worn by the MMU team members if they are required to enter the PAZ or an area which may be contaminated. It is unlikely that very high levels of surface contamination would exist outside the PAZ.

Plastic suits are normally disposed of after use, however they may be decontaminated and reused if necessary.

Cotton gloves may be worn in place of plastic gloves to prevent excessive perspiration of hands, however, if wet surfaces are to be handled then plastic gloves must be worn.

7. USE OF THE MONREP FORM

When carrying out field monitoring the results should be written on one of the MONREP forms kept in the kits (see Figure 3). The form also acts as a memory aid to ensure all the required measurements are made.

The section above on use of monitors, and the footnotes on the MONREP form detail the monitoring procedures such as air sample times and additional dose rate locations.

The MONREP form has space for 3 sets of results, mark 1 to 3 above the columns on the first form used and number other forms in sequence, ie 4 to 6 etc.

Some of the information on the MONREP form is routine information which does not need to be transmitted and this should be reported as "Blank". The footnotes specify this information. The pancake probe is only used if the NaI detector system fails and there is no replacement. Otherwise the pancake probe entries should also be reported as "Blank".

The Emergency Monitoring Report (MONREP) form is designed to facilitate clear and concise reporting of monitoring results by radio. Figure 3 is an example of a MONREP reporting form.

Figure 3. Emergency Monitoring (MONREP) Form

Revised July 2005

Mobile call sign	Alphabet serial	MONREP number[1]		
Air Sample:				
Location; map	Alpha	______	______	______
GPS (top line)	Bravo	______	______	______
GPS (bottom line)	Charlie	______	______	______
Time On	Delta	______	______	______
Elapsed Time	Echo[2]	______	______	______
Pump Flow Rate	Foxtrot[3]	______	______	______
Eberline with Nal probe:				
Background	Golf[4]	______	______	______
Sample	Hotel[5]	______	______	______
Calibration	India[6]	______	______	______
Only use if instructed.				
Pancake probe:				
Background	Juliet[4]	______	______	______
Sample	Kilo[5]	______	______	______
Calibration	Lima[6]	______	______	______
FAG (Dose Rate):				
Location 1	Mike[7]	______	______	______
μSv/h	November	______	______	______
Location 2	Oscar[8]	______	______	______
μSv/h	Papa	______	______	______
Weather:				
Wind Direction	Quebec[9]	______	______	______
Wind Speed (knots)	Romeo[10]	______	______	______

Details below are not for transmission

Kit No. ____________ MONREP Sent by (initials)/Time ____________ ____________ ____________

Vehicle Reg No. ____________

FOOTNOTES:

1. Enter each MONREP number sequentially, eg, for MMU 1 or Mobile 1, for the 3rd MONREP use M1.3 (report "Mike 1 decimal 3".)
2. **5 minutes** unless otherwise instructed.
3. As indicated in L/min on the pump calibration sticker.
4. Instrument backgrounds G and J should be taken well away from the samples.
5. Sample measurements H and K should be measured, ie **do NOT subtract the background**.
6. As indicated in cps/kBq I-131on the instrument calibration sticker.

*Note: In G to L, "**Blank**" should be reported for the instrument which is not used.

7. **Inside the vehicle**, unless otherwise instructed. Transmit "**Blank**" **if inside the vehicle.**
8. **10 m from the vehicle**, unless otherwise instructed. **Transmit "Blank" if 10 m from the vehicle.**
9. Averaged over 5 minutes using the compass in the kit.
10. Averaged over 5 minutes using the meter in the kit.

7.1 Communicating a MONREP by Radio/Mobile Phone

When communicating the results by radio/mobile phone, it is unnecessary to say the words Location, Time On, Time Elapsed, etc, instead use the alphabetical serial as shown below which is also written on the MONREP form.

A – Alpha	H – Hotel	O - Oscar	V – Victor
B – Bravo	I – India	P - Papa	W – Whiskey
C – Charlie	J – Juliet	Q - Quebec	X - X-ray
D – Delta	K – Kilo	R - Romeo	Y – Yankee
E – Echo	L – Lima	S - Sierra	Z – Zulu
F – Foxtrot	M – Mike	T - Tango	
G – Golf	N - November	U - Uniform	

To use a radio transceiver, hold down the "send" button and say:

BASE *(base call sign),* THIS IS MOBILE *(your call sign)* MONREP FOLLOWS, OVER Release button. Base will reply:

THIS IS BASE, SEND MONREP, OVER

You reply: BASE THIS IS MOBILE *(your call sign),* MONREP NUMBER *(give monrep number)* FOLLOWS, ALPHA *(give data),* BRAVO *(give data),* CHARLIE *(give data),* etc, etc. OVER.

7.1.1 If the alphabet serial item is not recorded, report "blank".

7.1.2 If a decimal, do not say point, say "decimal" and if less than one, always include the word zero,

eg for 0.5, do not say "point five", say ZERO DECIMAL FIVE.

7.1.3 If base says

SAY AGAIN MONREP

the full monitoring report is given again.

If base says

SAY AGAIN GOLF

the reading adjacent to Golf is given.

7.1.4 At the bottom of the MONREP column indicate the time the message was sent and initial it.

7.2 Use of MONREP Message in Form and Processing the Field Data

When the MMU transmits their MONREP detailing their field measurements to the EOC, the communication officer should enter the details on a "MONREP message in" form for the removal/exposure time for that port and the type of vessel, see below. The completed

"MONREP message in" form should be passed to the LRMG/SRO/TRO, who will then check the results to confirm they are consistent with other measurements and the type of incident. The LRMG/SRO/TRO will ensure the air sample calculations are carried out and these results, along with the dose rate data, are assigned the colour coding in Table 4 for the vessel removal time. These colours correspond to the Protective Actions detailed in Table 5. The information regarding the appropriate colour, the measurement location and the time of the measurement will be passed to the plotter to be indicated on the "situation map". In some situations some of these actions will be carried out "electronically".

Table 4
Colour Coding to be Applied to MONREP Field Data

Removal time	MONREP results	Green	Blue	Yellow	Red
Removal time 12 to 24 hours*	Y or Z $kBq\ m^{-3}$	Less than 3	Equal or greater than 3	Equal or greater than 15	*Equal or greater than 60
	N or P $\mu Sv\ h^{-1}$	Less than 6	Equal or greater than 6	Equal or greater than 30	Equal or greater than 300
Removal time 6 hours		Green	Blue	Yellow	Red
	Y or Z $kBq\ m^{-3}$	Less than 6	Equal or greater than 6	Equal or greater than 33	*Equal or greater than 120
	N or P $\mu Sv\ h^{-1}$	Less than 13	Equal or greater than 13	Equal or greater than 66	Equal or greater than 660
Removal time 4 hours		Green	Blue	Yellow	Red
	Y or Z $kBq\ m^{-3}$	Less than 10	Equal or greater than 10	Equal or greater than 50	*Equal or greater than 180
	N or P $\mu Sv\ h^{-1}$	Less than 20	Equal or greater than 20	Equal or greater than 100	Equal or greater than 1000
Removal time 2 hours		Green	Blue	Yellow	Red
	Y or Z $kBq\ m^{-3}$	Less than 20	Equal or greater than 20	Equal or greater than 100	*Equal or greater than 360
	N or P $\mu Sv\ h^{-1}$	Less than 40	Equal or greater than 40	Equal or greater than 200	Equal or greater than 2000

It must be remembered that the above values are based on projected doses over the expected exposure/removal time. The SRO/TRO may decide not to implement protective actions indicated in Table 5 if they feel the avertable dose does not justify the action. An example of this would be where the vessel is already being moved from the berth/anchorage. If removal/exposure times other than those quoted above are appropriate, new values can be calculated simply by taking a ratio of the times and applying it to the OILs.

*In RPS 7 there is no evacuation level quoted for the committed effective dose due to inhalation. A value for the total effective dose in terms of the inhalation of I-131 has been calculated and given for guidance. The values quoted in the table have been calculated assuming the dose from I-131 accounts for 30% of the total effective dose, as indicated in Table 6.1-9 of ref 4. The most restrictive dose conversion factors for adult and child (7 to 10 y) have been taken from IAEA BSS-115 and used in conjunction with appropriate breathing rates from RPS 7.

Level for Evacuation = 50 mSv, therefore that due to I-131 = 15 mSv.

Ref 3: Breathing rate for adult 1.5 $m^3 h^{-1}$,
Breathing rate for child 1.12 $m^3 h^{-1}$

Dose conversion factor for adult 7.4 E-09 Sv/Bq
Dose conversion factor for adult 1.9 E-08 Sv/Bq

15 mSv equates to an intake of 15 E-03/7.4E-09 = 2 MBq for an adults and
15E-03/1.9E-08 = 0.8 MBq for a child

For 12 h exposures the I-131 concentration leading to a 15 mSv committed effective dose would be as follows:

Adult = 2 MBq/1.5$m^3 h^{-1}$ *12 = 110 kBq m^{-3}
Child = 0.8 MBq/1.12$m^3 h^{-1}$*12 = 60 kBq m^{-3}

The child value is the most restrictive and has been used in the table. For exposure/removal times other than 12 hours the value is pro-rata of that time.

Table 5
Colour Coding for Protective Actions to be Taken

	External Radiation Hazard	Iodine -131 Measurement in Air
Green	No Action/reassure	No Action/reassure
Blue	Issue stable iodine to children (<18y) if radioiodine has been confirmed by air sample	Issue stable iodine to children (<18y)
Yellow	Shelter Also issue stable iodine to adults and children (<18y) if radioiodine has been confirmed by air sample	Issue stable iodine to adults and children (<18y)
Red	Evacuate	Evacuate

Figure 4. MONREP - MESSAGE IN Form for 2 Hour Removal Time

Revised August 2005

TIME /DATE:

FROM TEAM:

TEXT:

MONREP Number:	**#**	**Calculations**
Air Sample: Location GPS (top line) GPS (bottom line) Time On Elapsed Time Pump Flow Rate	**A** .... **B** .... **C** .... **D** .... **E** **F**	**Using Eberline Results:** Sample **H** – Background **G** = ... cps Vol of air sampled **E x F**= .... L Calibration Factor **I** = ... cps/kBq Concentration of I-131 = Y Y = (H-G)/(ExF)x1000/I kBqm^3 **Y = ... kBq m^{-3}**
Eberline with NaI probe: Background Sample Calibration **Pancake probe:** Background Sample Calibration	 **G** .... **H** .... **I** .... **J** .... **K** .... **L**	**Using Pancake Probe Results:** Sample **K** - Background **J** = ... cps Vol. of air sampled E x F = ... L Calibration Factor **L** = ... cps/kBq Concentration of I 13 1 = Z Z = (K-J)/(ExF)x1000/L kBq/m^3 **Z = ... kBq m^{-3}**
FAG (Dose Rate) Location 1 µSv/h Location 2 µSv/h	 **M** .... **N** .... **O** .... **P**	**FAG Results:** Dose Rate **N** = ... µSv h^{-1} Dose Rate **P** = ... µSv h^{-1}
Weather: Wind Direction Wind Speed (knots)	 **Q** .... **R**	Wind Speed = **R/2** = ... **m/sec**

PLOTTING COLOUR CODE: Highest Colour is:

Compare your results **P, Q, L, N** with the adjacent table; then circle the highest colour value and plot the colour point on the plotting map		**Green**	**Blue**	**Yellow**	**Red**
	Y or **Z**	Less than 20	≥ 20	≥ 100	≥ 360
	N or **P**	Less than 40	≥ 40	≥ 200	≥ 2000

Received by: ....

Plotted by: ....

Checked by LRMG or SRO/TRO: .... **Time:** ....

WARNING: If vessel is delayed beyond 2 hours revise to more restrictive OILs

Figure 5. MONREP - MESSAGE IN Form for 12 to 24 Hour Removal Time

Revised August 2005

TIME /DATE:		
FROM TEAM:		
TEXT:		
MONREP Number:	**#**	**Calculations**
Air Sample: Location GPS (top line) GPS (bottom line) Time On Elapsed Time Pump Flow Rate	**A** .... **B** .... **C** .... **D** .... **E** .... **F**	**Using Eberline Results**: Sample **H** – Background **G** = ... cps Vol of air sampled **E x F**= .... L Calibration Factor **I** = ... cps/kBq Concentration of I-131 = Y $Y = (H-G)/(ExF)x1000/I\ kBqm^{-3}$ **Y = ... kBq m^{-3}**
Eberline with NaI probe: Background Sample Calibration **Pancake probe**: Background Sample Calibration	 **G** .... **H** .... **I** .... **J** .... **K** .... **L**	**Using Pancake Probe Results**: Sample K - Background **J** = ... cps Vol. of air sampled E **x F** = ... L Calibration Factor **L** = ... cps/kBq Concentration of I 13 1 = Z $Z = (K-J)/(ExF)x1000/L\ kBq\ m^{-3}$ **Z = ... kBq m^{-3}**
FAG (Dose Rate) Location 1 µSv/h Location 2 µSv/h	 **M** .... **N** .... **O** .... **P**	**FAG Results:** Dose Rate **N** = ... µSv h^{-1} Dose Rate **P** = ... µSv h^{-1}
Weather: Wind Direction Wind Speed (knots)	 **Q** .... **R**	Wind Speed = **R/2** = ... **m/sec**

PLOTTING COLOUR CODE: Highest Colour is:

Compare your results **P, Q, L, N** with the adjacent table; then circle the highest colour value and plot the colour point on the plotting map		**Green**	**Blue**	**Yellow**	**Red**
	Y or **Z**	Less than 3	≥ 3	≥ 15	≥ 60
	N or **P**	Less than 6	≥ 6	≥ 30	≥ 300

Received by: ....

Plotted by: ....

Checked by LRMG or SRO/TRO: .... **Time:** ....

7.2.1 Plotting field measurement data

The LRMG/SRO/TRO will provide details of the colour to be plotted on the "situation map" to a "plotter". The plotter will place an appropriate coloured marker on the map corresponding to the location where the measurement was made. The time of the measurement should be written on the marker.

In some locations the plotting may be carried out "electronically".

8. CALCULATION OF AIRBORNE CONTAMINATION LEVELS

Air sample data are recorded on a radiation monitoring report (MONREP) form which is then used to transmit the data from the Mobile Monitoring Units by radio or mobile phone to the Duty Officer at the EOC. The EOC Duty Officer or a communications officer transcribes the data to a MONREP IN form which is then passed to a Calculations and Plotting Officer. Calculations should be made by this officer and the results plotted and communicated to the State Radiation Officer. Note: A number of organisations have computerised the data receipt and subsequent calculation process.

8.1 Using NaI Detector Field Results

The following formula should be used to calculate the amount of iodine-131 (I-131) in a Maypack sample:

$$Y = \frac{1000\,(H-G)}{EFI}\ \text{kBq/m}^3\,(\text{I-131})$$

where:

H = Sample measurement including background (cps),
G = Background (cps),
E = Elapsed time (min),
F = Pump flow rate (L/min), and
I = Calibration factor on instrument label (cps per kBq of I-131).

8.2 Using GM Pancake Probe Detector Field Results

The following formula should be used to calculate the amount of I-131 in a Maypack sample:

$$Z = \frac{1000\,(K-J)}{EFL}\ \text{kBq/m}^3\,(\text{I-131})$$

where:

K = Sample measurement including background (cps),
J = Background (cps),
E = Elapsed time (min),
F = Pump flow rate (L/min), and
L = Calibration factor on instrument label (cps per kBq of I-131).

A number of iodine radioisotopes are likely to be present in the air sample cartridge following sampling. The OILs used in this handbook use Iodine-131 (I-131) as a marker radionuclide and the calibration factors for the probes have therefore been assessed to convert the total activity measured to I-131.

9. CONTAMINATION MONITORING AT CONTAMINATION CONTROL POINTS

Contamination control points should be specified in the Port Safety Arrangements during the planning stages of a visit. These control points should be near the PAZ (previously called Zone 1) but in a location that is unlikely to be affected by any radioactive plume from the vessel. The contamination control point would usually be located near where the port security control points have been set up. Alternative locations may need to be designated if changes in wind direction could result in significant exposure in the area. Persons and vehicles leaving PAZ (previously called Zone 1) after an accident should be checked for contamination and decontaminated if necessary.

Procedures dealing with monitoring, decontamination facilities and method, waste control and recording of personal details should be available. These procedures are not part of this handbook and guidance is available elsewhere. The SRO/TRO is responsible for health physics coverage and arrangements for these points.

10. REFERENCES

1. Department of Defence. Defence Operations Manual (OPSMAN 1), Visits to Australia by Nuclear-Powered Warships.

2. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *Recommendations, Intervention in Emergency Situations Involving Radiation Exposure.* Radiation Health Series No. 7 (RPS 7), ARPANSA, Yallambie.

3. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Technical Report; The Environmental Monitoring Handbook for the Visits of Nuclear Powered Warships.

4. Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). The 2000 Reference Accident Used to Assess the Suitability of Australian Ports for Visits by Nuclear Powered Warships. RB - NPW - 66/00.

Appendix 1 Gamma Spectra Analysis Of Air Samples

Air samples with positive results should be collected from monitoring teams by a courier and taken to the EOC where the gamma spectrometer is set up. This instrument should be left switched on and be operational for the duration of the NPW visit. The LRMG should calibrate the system with a TC-45 spiked with a known activity of I-131. The region of interest (ROI) for the main 364 keV I-131 peak should be set at the "full width half max" (FWHM) and the count efficiency calculated, see calculation 1 below. Information on setting up and calibration of the gamma spectrometer is provided in manuals in the kit.

Calculation 1. Efficiency of NaI Detector for I-131 Spiked TC-45 Cartridge

Efficiency = (TC-45 counts in ROI – Background counts in ROI)/count time in seconds*Activity in Bq.

COUNTING TC-45 AIR SAMPLE CARTRIDGE

Airborne radioiodines will be collected and trapped in the TC-45 cartridge and will not penetrate more than a few millimetres into the cartridge. Particulate radioactive materials, such as caesium-137 will have been trapped on the filter paper which has been placed in another plastic bag and may be counted at a later time.

Place the plastic bag containing the TC-45 cartridge on the gamma spectrometers detector, with the arrow marked on the side of the cartridge pointing away from the detector.

Sample and background counts should be accumulated for at least 100 seconds. The concentration of I-131 in the air at the sample location can then be calculated as shown in calculation 2 below.

Calculation 2. Calculation of Air Sample Concentrations using the Gamma Spectrometer

The following formula should be used to calculate the amount of I-131 on a sample:

$$C = \frac{1000(Sc - Bc)}{Eff.E.F} \text{ kBq m}^{-3} \text{ (I-131)}$$

where:

C = Concentration of I-131 kBq m^{-3},
Sc = Sample cps (corrected for dead time),
Bc = Background cps (corrected for dead time),
Eff = Efficiency for I-131,
E = Elapsed air sampling time (min), and
F = Pump flow rate (L/min).

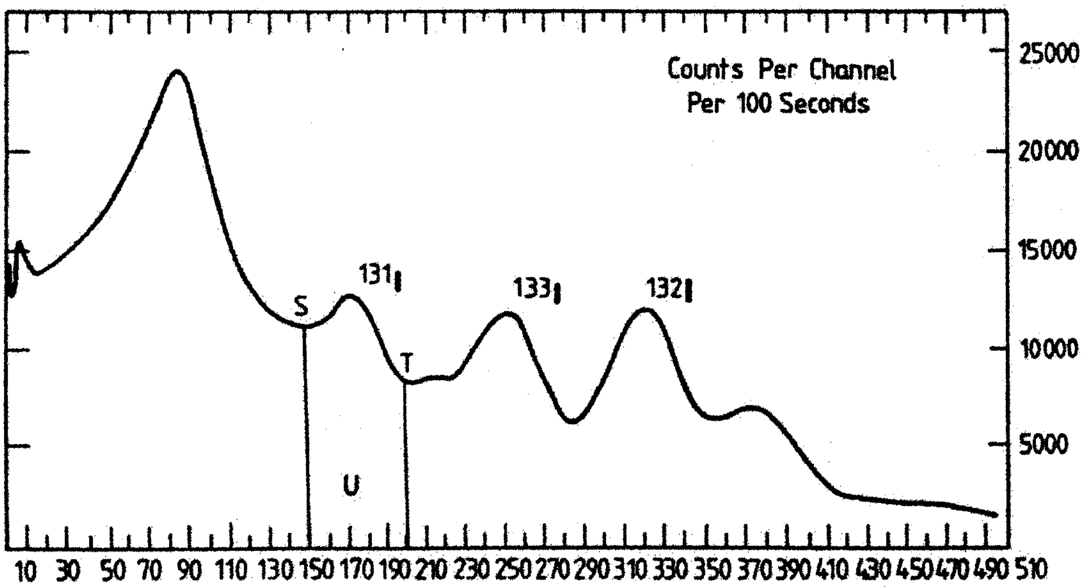
All counts must be made for the same period of time. A typical counting time would be 100 seconds. If necessary the filter paper can be counted and the air concentration of other radionuclides estimated in a similar manner.

The energies and abundances of gamma emissions from some important nuclides are listed in the Table below.

Table 6
Nuclear Emission Data for Selected Fission Products

Isotope	Half-life	Particle type and energies (MeV)	Gamma energies (MeV)
Kr-85m	4.4h	IT 19% β - 0.82 81%	0.305 13% 0.15 78%
Kr-85	10.6y	β - 0.15 0.7% 0.67 99.3%	0.51 0.7%
Rb-88	17.7m	β - 2.5 9% 3.6 13% 5.3 78% plus others	0.91 15% 1.39 1.4% 1.85 23% 2.11 1% 2.68 2.5% 3 to 4.9 weak
Ru-103	40.0d	β - 0.2 89.4% plus others	0.498 88% plus others
Ru-106 daughter Rh-106	1.0y 30.0s	β - 0.039 100% β - 1.5 to 3.6	 0.51 to 2.9
Cs-137	30.0y	β - 0.51 95% 1.17 5%	0.662 86% via 2.6m Ba-137m
I-131	8.0d	β - 0.61 87.2% plus others	0.08 2.2% 0.28 6.3% 0.36 79% 0.64 9.3% 0.72 2.8%
I-132	2.3h	β - 0.80 21% 1.04 15% 1.22 12% 1.49 12% 1.61 21% 2.14 18%	0.38 4.8% 0.52 21.5% 0.62 5.2% 0.65 26% 0.67 100% 0.72 6.5% 0.78 84% 0.95 21% 1.14 5% 1.30 4% 1.39 8.5% plus others
I-133	20.8h		0.53 100% 0.88 5%
I-135	6.7h		0.29 11.7% 0.42 12.5% 0.53 45% via 15.3m Xe-123m 0.55 24.8% 0.84 22.5% 1.1 76.4% 1.26 100% 1.46 30.4% 1.68 34.1%
Te-132 daughter I-132	78.0h 2.3h	β - 0.22 100% β - 0.73 to 2.12	0.23 95% I-132 as above
Xe-133m	2.3d	IT 100%	0.23 13.5
Xe-133	5.3d	β - 0.34 99%	0.081 35.5

Figure 6. Example of Possible Gamma Spectrum of an Air Sample



Appendix 2 Weather Forecasts

Arrangements should be made, under the provisions of the Port Safety Plans, for the Bureau of Meteorology Regional Forecasting Centre nearest to the port, to supply the Duty Officer the following information on request.

For each visit forecasts should be obtained as per Figure 7 for the anchorage or berth on at least a six hourly basis. (Note that this form has been tailored for Hobart and should be customised for the local port in question.) The purpose of this forecast is to provide the LRMG with access to general weather guidance and sufficient information to make initial decisions should an incident occur.

If an incident occurs Observations and Forecasts should be obtained on an hourly basis as per Figure 8 (Observations) and Figure 9 (Forecasts). (Note again that these reporting formats have been tailored for Hobart and should be customised for the local port in question.) The purpose of these reports is to provide the LRMG and SRO/TRO with detailed weather observations and short term forecasts, sufficient to make detailed decisions during an incident. Ideally the Bureau of Meteorology should be asked, again under the provisions of the Port Safety Plans, to provide, where possible, a forecaster at the Emergency Operations Centre, to assist with the interpretation of weather information and to assist with any small scale forecasting required.

Note: Units are: wind speed in knots (knots/2 = m/sec); wind direction is the direction **from which the wind is coming** as measured in degrees, clockwise from north, eg, 270 is a wind coming from the west (a westerly), going to the east; elevations are in metres; and visibility (if referred to in the weather section) will be in nautical miles.

Figure 7. Nuclear Powered Warship - Routine Weather Forecasts (Issued at 5 am, 11 am, 5 pm and 11 pm)

Bureau of Meteorology, Hobart

Issued at .... (local time/day/date)

Valid for 6 hours from time of issue at anchorage

If NO wind change is expected:

- Forecast average wind speed: .... (knots)
- Forecast average wind direction: .... (degrees)
- Forecast weather:
- Forecast Pasquill Stability Class: A, B, C, D, E, F, G *(circle forecast, delete others)*

If wind change IS expected:

- Forecast wind change expected at: .... Local time
- Forecast average wind speed ahead change: .... (knots)
- Forecast average wind direction ahead change: .... (degrees)
- Forecast weather ahead change:
- Forecast Pasquill Stability Class ahead change: A, B, C, D, E, F, G *(circle forecast, delete others)*
- Forecast average wind speed behind change: .... (knots)
- Forecast average wind direction behind change: .... (degrees)
- Forecast weather behind change:
- Forecast Pasquill Stability Class behind change: A, B, C, D, E, F, G *(circle forecast, delete others)*

Outlook for further 12 hours: ....

....

For further information contact forecaster on: ....

Figure 8. Nuclear Incident Weather Observation Form

Upper air observations

Hobart Airport upper air at .... (local time) .... (day/date)

Height (metres)	**Wind direction** (degrees)	**Wind speed** (knots)	**Air temperature** (degrees C)
300			
600			
900			
1500			

Cloud amount over incident site:
(Circle one, cross out the others)

Sky was overcast
Sky was more than half covered
Sky was clear or less than half covered

Ground level observations

Surface observations at .... (local time) .... (day/date)

Location	**Elevation** (metres)	**Wind direction** (degrees)	**Wind speed** (knots)	**Air temperature** (degrees C)
Ellerslie Rd	55			
Marine Tower	35			
Tasman Bridge	60			
Marine Raft	3			
Droughty Hill	150			
Hobart Airport	4			
Mt Wellington	1270			

Pasquill stability category
(Circle relevant one, cross out the others)

A Very unstable
B Moderately unstable
C Slightly unstable
D Neutral
E Slightly stable
F Moderately stable
G Very stable

Figure 9. Nuclear Incident Weather Forecast Form

Forecasts issued at .... (local time/day/date)

Valid for TWO hours from time of issue at anchorage

Forecasts for upper air over the Hobart area

Height (metres)	**Wind direction** (degrees)	**Wind speed** (knots)	**Temperature** (degrees C)
300			
600			
900			
1500			

Forecast cloud amount over incident site
(Circle one, cross out the others)

Sky was overcast
Sky was more than half covered
Sky was clear or less than half covered

Forecasts for selected surface locations

Location	**Elevation** (metres)	**Wind direction** (degrees)	**Wind speed** (knots)	**Air temperature** (degrees C)
Ellerslie Rd	55			
Hobart Airport	4			
Mt Wellington	1270			

Forecast Pasquill stability category
(Circle relevant one, cross out the others)

A Very unstable
B Moderately unstable
C Slightly unstable
D Neutral
E Slightly stable
F Moderately stable
G Very stable

Appendix 3 Recommended Stable Iodine Doses

Table A1: RECOMMENDED SINGLE DOSES OF STABLE IODINE ACCORDING TO AGE GROUP (RPS 7)

Age group	Mass of stable iodine (mg)	Mass of potassium iodide (mg)	Mass of potassium iodate (mg)	Fraction of 100 mg (stable iodine) tablet
Neonates (birth to one month)	12.5	16	21	1/8
Infants (one month to 3 years)	25	32	42	1/4
Children (3 - 12 years)	50	65	85	1/2
Adolescents (over 12 years) and adults (including pregnant women and lactating mothers)	100	130	170	1

The dose for neonates is critical. The single dose of 12.5 mg stable iodine should not be exceeded. Potassium iodide solution may be used for accurate dosage or whole tablets may be divided, crushed and dissolved in milk or water and the appropriate fraction of the liquid administered to the infant.

In an emergency, administration of only one dose of stable iodine, which provides protection for 24 hours, should be sufficient to protect against the effects of inhaled radioiodine. Other interventions, including evacuation and control of foodstuffs if necessary, should be implemented to reduce the possibility of longer-term exposure to radioiodine via ingestion. Emergency workers may require longer-term protection against radioiodine and may then take one tablet every twenty-four hours, for a maximum of ten days, if necessary (see note below).

Contraindications

The WHO (WHO 1999) has indicated the following contraindications:

- past or present thyroid disease (eg, active hyperthyroidism),
- known iodine hypersensitivity,
- Dermatitis herpetiformis,
- Hypocomplementaemic vasculitis.

NOTE: It should be ensured that all emergency personnel who may enter any area where the issue of stable iodine is ordered should be asked about whether they have an allergy to iodine. Persons with an iodine allergy should not be sent into areas where iodine prophylaxis is required.