CHAPTER 11

RADIOLOGICAL DEFENSE AND RECOVERY

Learning Objectives: Recall the different types of radioactivity, detection, indication, and computation (RADIAC) and dosimeter instruments and their design limitations, the different types of radiological surveys, and the different types of exposure control.

Radiological defense is a very important part of the ship's recovery phase. Radiological defense is the area of nuclear survivability that is most subject to management by the ship. Even if the ship is physically unaffected, the overall mission capability will be reduced by the effects of radiation on the crew. The radiological hazard can endanger ships in areas hundreds of miles from surface zero and it lasts the longest of any of the nuclear weapon effects. That is why it is important to minimize the radiological hazard to personnel through the proper use of radiological defense and recovery procedures.

RADIAC INSTRUMENTS USED FOR RADIOLOGICAL DEFENSE

Learning Objective: Recall the different types of RADIAC and dosimeter instruments and their design limitations.

Nuclear radiation once present cannot be detected by any of the five senses. Therefore, special instruments and devices have been developed to do this job. From the military standpoint, we not only need to detect radioactivity but we also need to know where the radiation is and what the intensity is. RADIAC instruments serve both of these needs and are designed to perform the following functions:

- Detect beta and gamma radiation.
- Measure the intensity of radiation.
- Measure radiation dose.
- Determine the extent of contamination.
- Provide information for calculating the length of time that contamination will exist in the area.
- Determine the effectiveness of decontamination measures.

NOTE

This chapter presents a brief introduction to specific radiac instruments you may use. Detailed information on this subject is found in the *Naval Ships'Technical Manual* (*NSTM*), chapter 070.

TYPES OF RADIAC INSTRUMENTS

The detection of nuclear radiation is of vital importance to personnel. Serious injury or death can result from exposure to sufficient quantities of these invisible rays and particles. In considering the effects on personnel exposed to radiation, we need two kinds of information:

1. The intensity of the radiation field
2. The total dose or quantity of radiation received per exposure or time interval

"INTENSITY" may be defined as the strength of the radiation. It is expressed as a quantity of radiation per unit of time. The quantity unit used is the roentgen or the rad, and the time unit is usually the hour. Therefore, you need to remember the following:

- INTENSITY is expressed as roentgens per hour (R/hr) or as rads per hour (rad/hr).
- DOSAGE is expressed in two values: the EXPOSURE DOSE, measured in roentgens, and the ABSORBED DOSE, measured in rads.

NOTE

A **roentgen** is a unit of radiation dosage equal to the quantity of ionizing radiation that will produce one electrostatic unit of electricity in one cubic centimeter of dry air at 0° Centigrade and standard atmospheric pressure.

A **rad** is a unit of energy absorbed from ionizing radiation, equal to 100 ergs per gram of irradiated material. An added factor in the use of a rad is that it expresses the dose from any type of radiation, whereas the roentgen relates only to gamma radiation or X rays.

Information on intensity and dosage is essential in measuring the extent and degree of radiological contamination. It permits the calculation of safe entry time and stay time for personnel in contaminated areas. Also, it provides an objective means for withdrawing personnel when they are nearing the critical point of radiation exposure. Finally, it is useful in anticipating the severity of radiation sickness. Data needed for these and other calculations can be gathered by various radiac instruments.

No hand-held RADIAC available for military use can measure both radiation intensity and dose. Therefore, separate instruments must be used to make the different types of measurements. These devices are as follows:

- DOSE RATE, or SURVEY METER—The device that measures radiation intensity is called a dose rate, or survey, meter. This device provides the information needed to calculate the radiological hazards of occupying a contaminated area or handling contaminated equipment. It also provides the information necessary to calculate the approximate length of time personnel can safely remain in a radiological contaminated area.

- DOSIMETER—The device that measures the total radiation received by an individual is called a dosimeter. Medical officers must have dose information to predict the severity of radiation sickness, to make the prognosis, and to provide appropriate medical treatment.

The two types of radiation detection and measuring instruments may be compared to automobile speedometers and odometers (mileage indicators). The dose rate, or survey, meter measures the intensity of radiation in R/hr or rad/hr like the speedometer indicates the speed of an automobile in miles per hour. The dosimeter measures the total exposure in R or in rad, without regard to time. Therefore, it is like the odometer that records the total distance traveled in miles without regard to time.

Fixed RADIAC systems are installed on most Navy combatants. The instruments provide information on gamma dose rates at the location of the detector and at the main readout installations, usually the bridge area and DCC (Damage Control Central). The information from these instruments may be used to estimate the dose rates at locations on the ship other than the bridge.

SURVEY METERS

The Navy has radiac instruments that can be used to detect or measure certain types of radiation. The following sections discuss the survey meters currently used by the Navy.

AN/PDR-27

The AN/PDR-27 (series J through S) shown in figure 11-1 is a portable, watertight, battery-powered, low-range survey radiac. Two Geiger-Mueller (GM) tubes are mounted in an extendable probe. A spare GM tube set is included in the carrying case. The probe is fitted with a beta shield. Six alkaline D-cell batteries (BA-3030/u) power the unit. If the alkaline batteries are unavailable, you may use carbon-zinc, D-cell batteries (BA-30). The AN/PDR-27 provides both visual and audible indications of gamma and beta radiation levels. The visual indication is shown on a meter. The audible indication is heard through a headset. The radiation measurement is in milliroentgens per hour (mR/hr). The unit is capable of detecting and measuring gamma radiation when the beta shield is in place. It is also capable of detecting beta and gamma radiation simultaneously when the beta shield is removed. There are four linear scales on the AN/PDR-27. The scales are 0 to 0.5 mR/hr, 0 to 5 mR/hr, 0 to 50 mR/hr, and 0 to 500 mR/hr. Beta radiation can be detected on the lower two scales only. The -27 can detect and measure gamma, but it can only detect beta.

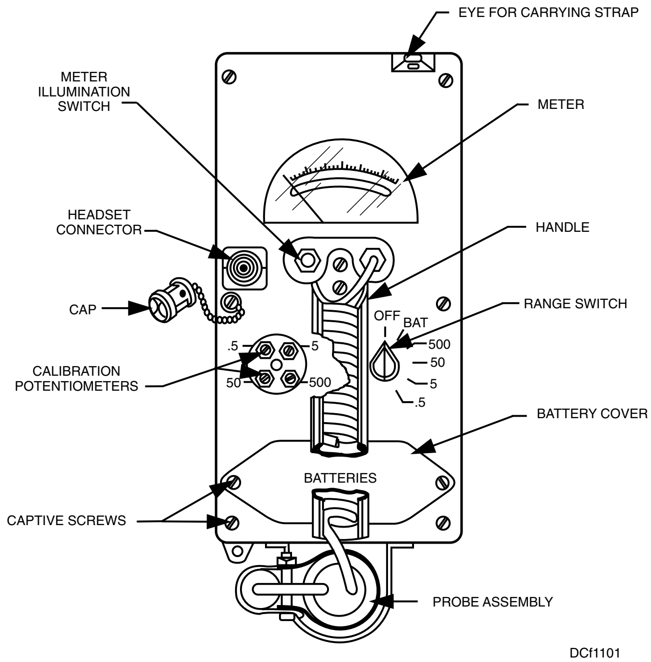


Figure 11-1. AN/PDR-27S radiac meter.

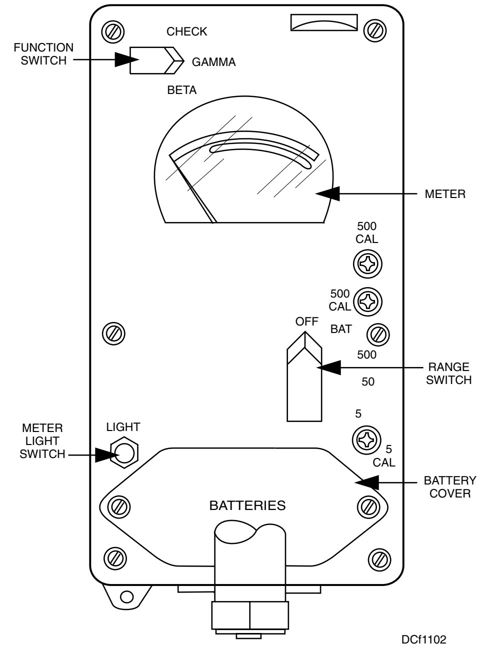


Figure 11-2. AN/PDR-43F radiac meter.

AN/PDR-43

The AN/PDR-43 shown in figure 11-2 is a battery-powered, high-range, beta-gamma RADIAC set used for low- and high-level surveys and, in some cases, personnel monitoring. It uses a GM detector and has a built-in Krypton-85 source to check for proper operation on all three operating ranges: 0-5 R/hr (gamma), 0-50 R/hr (gamma), and 0-500 R/hr (gamma). GM detectors, such as the AN/PDR-43 adjust quickly to changes in the level of radiation intensity. Even when shifting to a different range scale, only 1 second is required for meter adjustment. At intensities above 500 R/hr, the meter pegs but does not become saturated. It is calibrated to an accuracy of ±20 percent.

AN/PDR-65

The AN/PDR-65 shown in figure 11-3 is designed to detect and measure gamma radiation. The set consists of two primary elements as follows:

1. The DETECTOR UNIT. The detector unit must be located at or near a masthead. The field of view for the detector of an enveloping base surge cloud and resultant fallout must be relatively unobscured. As a result, if suitable scaling factors are available, gamma dose rates at any location inside the ship can be estimated from the masthead radiation intensity data.

2. The RADIAC METER. The radiac meter is installed on the bridge. One or more auxiliary readouts are located in DCC and other prime locations. The radiac meter has two types of displays—one is for dose rate and the other is for accumulated dose. The primary meter displays the dose rate. The small counter registers the accumulated dose in rads by counting the rad pulses from the detector. Each time a dose of 1 rad is accumulated, the radiac meter sounds a loud beep. The range of the small counter is 0 to 9,999 rad. Gamma intensity is indicated on one of the following four ranges: 0 to 10 rad/hr, 0 to 100 rad/hr, 0 to 1,000 rad/hr, and 0 to 10,000 rad/hr.

For normal operation, the AN/PDR-65 is powered by the 115-volt alternating current (vac) ship's power. In an emergency, the radiac operates on four internal, rechargeable, nickel-cadmium, C-cell batteries, which are on floating charge. The batteries can power the radiac for approximately 20 hours.

Dosimeters

A number of types of radiation dose-indicating devices (dosimeters) are in the Navy radiac system. Dosimeters of interest to the Damage Controlmen are the DT-60/PD, the CP-95A/PD, the IM-9/ PD, and the IM-143/PD.

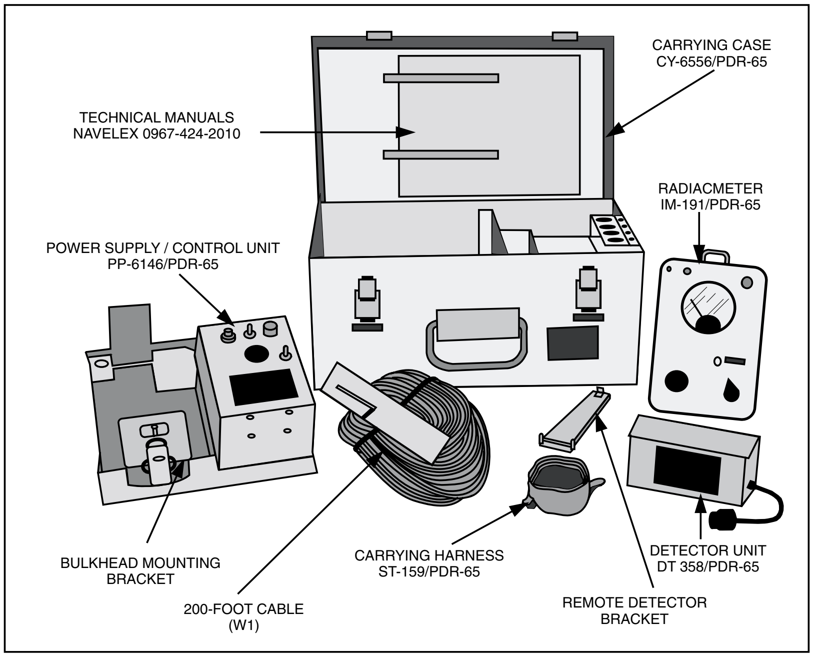


Figure 11-3. AN/PDR-65 radiac set.

DT-60/PD.—The DT-60/PD (fig. 11-4) is a gamma radiation dosimeter with a usable range of 10 to 600 R. The DT-60/PD is a solid-state package in the form of a locket designed to be worn on a chain around the neck. Inside the black plastic casing of the DT-60/PD is a phosphate glass. When the phosphate glass is exposed to ultraviolet light, it emits an orange light. The intensity of the orange light is proportional to the amount of radiation the glass has received. The DT-60/PD stores the dose information indefinitely and is a permanent record of the amount of exposure to radiation.

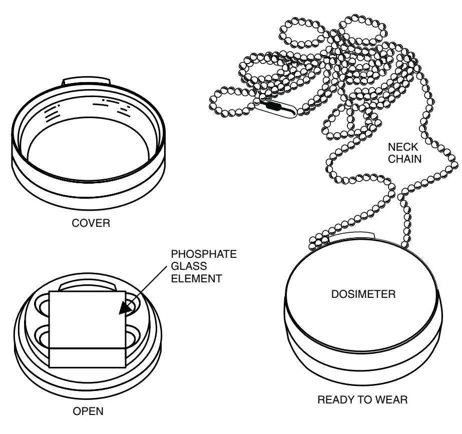


Figure 11-4. High range or casualty dosimeter (non-self-reading) DT-60/PD.

CP-95A/PD.—The CP-95A/PD (fig. 11-5) is a radiac computer-indicator that is used to read the amount of radiation a DT-60/PD has been exposed to. The cover on the DT-60/PD must be removed before the DT-60/PD is inserted into the radiac computer-indicator. Each of these radiac computer-indicators has two scales: 0 to 200 R and 0 to 600 R. However, 10 R is the minimum detectable exposure. These units have an accuracy rate of ±20 percent. The radiac computer-indicators operate off the ship's 115 vac power source.

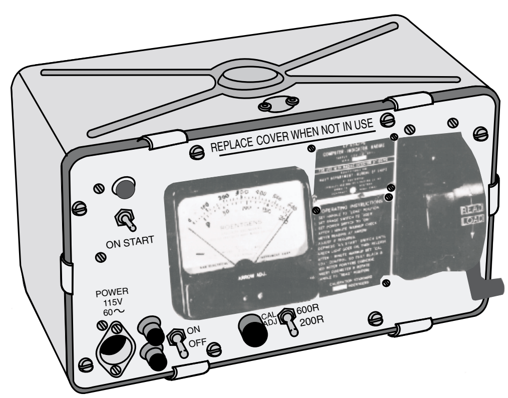
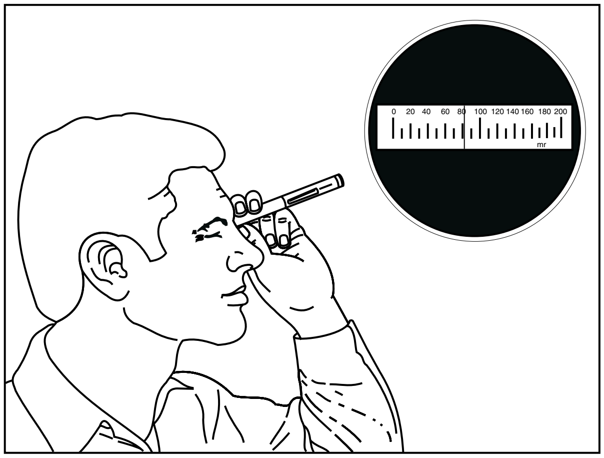


Figure 11-5. Radiac computer-indicator CP-95A/PD.

IM-9/PD.—The IM-9/PD (series E through H) is a self-reading pocket dosimeter of the quartz-fiber type. This unit indicates the gamma radiation dose in the range of 0 to 200 mR. By holding the dosimeter up to the light and looking through the lens (fig. 11-6), you can read the radiation dose received. The reading is obtained by observing the position of the quartz fiber on the scale of the built-in optical system. The IM-9/PD is primarily a health-physics device that is particularly useful in areas of low dose rates.



DCf1106

Figure 11-6. Method of reading IM-9/PD dosimeter by looking through it at the light. Inset shows a dose reading of 82 mR.

M-143/PD.—The IM-143/PD is identical to the IM-9/PD except in range. The IM-143/PD indicates gamma radiation dose in the range of 0 to 600 R. It is used by repair locker personnel that are involved with the survey, monitoring, and decontamination details during CBR evolutions. It keeps track of the dose they have received up to the time they read the dosimeter.

The PP-4276A/PD dosimeter charger (fig. 11-7) is used to reset the self-reading dosimeters to zero. This action is accomplished by placing the dosimeter into the charger. The charger provides an adjustable voltage source that is applied between the central wire and shell. Because the quartz fiber and the fixed central wire of the ion chamber are attached, each will receive the same charge. As a result, when the dosimeter is charged, the movable fiber is repelled from the fixed wire. By proper adjustment of the voltage applied by the charger, the fiber can be set exactly on the zero line of the scale. The power source for the PP-4276A/PD is one alkaline D-cell battery. When you charge a dosimeter with the PP-4276A/ PD, use the following procedures:

- Remove the dust cover from the charger receptacle.
- Place the electrode end of the dosimeter into the charging receptacle and depress it firmly. This illuminates the dosimeter scale and operates the charger.
- Rotate the charging knob until the hairline on the meter scale is located on the zero mark.
- Remove the dosimeter from the charger and check to ensure that it is still on zero.
- Replace the dust cover on the charger.

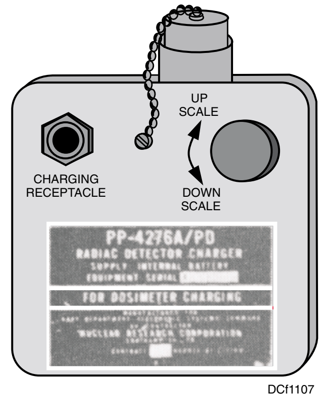


Figure 11-7. Dosimeter charger PP-4276A/PD.

LIMITATIONS OF RADIAC INSTRUMENTS

RADIAC equipment can detect and measure nuclear radiation; however, these instruments do have some limitations. None of the instruments are capable of detecting and measuring beta and gamma radiation at the same time. Even those that can detect both beta and gamma radiation do not automatically separate these two types of radiation. Instead, the operator keeps beta particles from entering the chamber by manually pulling a *beta shield* over the thin window in order to get a *gamma* reading only. Otherwise, you would get a combined reading.

CALIBRATION AND REPAIR OF RADIAC EQUIPMENT

RADIAC equipment aboard ship is checked as required by the *Ships' Maintenance and Material Management (3-M) Manual*. Ashore, radiac equipment is checked at least once each month or at intervals specified by the applicable technical manual. This check is accomplished according to instructions contained in the operator's section of the technical manual. RADIAC equipment must be temporarily transferred at regular intervals by shore activities to a radiac repair facility for maintenance and calibration. Ships, as far as practical within their operating schedules, also must transfer their radiac instruments to repair facilities for maintenance and calibration. When equipment requiring outside maintenance is found to be inoperative or is suspected of malfunctioning, it should be sent to the radiac repair facility immediately.

WARNING

Extreme care must be taken when performing routine maintenance on radiac instruments. Some of the instruments have complicated electronic circuits that can carry high voltages, which can present a hazardous condition for personnel. Other instruments contain radioactive material inside that presents a potential hazard if untrained personnel disassemble them. Remember that all radiac equipment that operates on direct current is designed so you can replace the batteries without exposing the internal circuitry or making the radiation hazard more dangerous.

The following checks should be made at least monthly:

- Battery check.
- Function check.
- Ensure instrument is turned off.
- Ensure instrument is stored in a cool, dry place. You may change the batteries for the radiac if they are weak. However, changing batteries does not eliminate the need for routine maintenance.

REVIEW QUESTIONS

Q1. Nuclear radiation cannot be detected by any of the five senses.

1. True
2. False

Q2. Which of the following is NOT a performance function of a radiac device?

1. Detect beta and gamma radiation
2. Measure the intensity of radiation
3. Measure radiation dose
4. Detect neutron and X-ray radiation

Q3. The AN/PDR-43 unit has three-meter scales.

1. True
2. False

Q4. What is the maximum amount of time the AN/PDR-65 will operate on fully charged batteries?

1. 10 hours
2. 20 hours
3. 30 hours
4. 40 hours

Q5. The DT-60/PD is a gamma radiation dosimeter with a usable range of 10 to 600R.

1. True
2. False

Q6. No hand-held radiac available for military use will measure both radiation intensity and dose.

1. True
2. False

RADIOLOGICAL SURVEYS

Learning Objective: Recall the different types of radiological surveys.

Radiological surveys are one of the key elements that provide the ship's personnel information needed for the recovery phase of operations. Radiological surveys are taken to determine radiation levels and deposition patterns after the ship has been contaminated by nuclear fallout.

There are several different types of surveys. It is essential that the exact time and location of each measurement is recorded and that the serial number of the RADIAC instrument used is indicated. The Radiological Survey Form shown in table 11-1 provides a format that can be used to record measurements from any type of survey.

Survey data is used to accomplish some critical tasks. These tasks include the following:

1. Detection of intrusion of radiological contamination into the interior of the ship.
2. Calculation of safe stay times for personnel at vital stations and on decontamination or monitoring teams.
3. Identification of topside locations that may require decontamination.

Table 11-1. Radiological Survey Form

SHIP: TYPE SURVEY: ROUTE NUMBER: SHEET NUMBER: EXIT:	DATE: MONITOR: INSTRUMENT TYPE: INSTRUMENT SERIAL: REENTRY:

NUMBER	AREA/OBJECT	TIME	METER READING/INDICATION		
			POSITION	SHIELD OPEN	SHIELD CLOSED

INSTRUCTIONS:

1. Routes to be established in advance.
2. Do not record RADIAC measurements in SHIELD OPEN column. Enter either BETA or NO BETA.
3. Time of wipe test is the time measurement is made, not time sample was taken.
4. Do not record a gamma (SHIELD CLOSED) measurement on an uncontrolled wipe test. If there is removable contamination (RC), enter RC. If there is none, enter NO RC. Do not record a beta (SHIELD OPEN) measurement on either type of wipe test, only RC or NO RC.
5. POSITION column notations indicate location at which measurement is taken: 3' ABOVE DECK to indicate waist height area monitoring; OPERATOR to indicate normal watchstander position at waist height; CONTROLLED WIPE TEST and UNCONTROLLED WIPE TEST to indicate wipe samples.
6. Readings may fluctuate as RADIAC instrument is rotated through various orientations at the same position. Always record highest measurement obtained.
7. Leave at least two blank rows to record hot spots along survey route.

ON-STATION MONITORING

Before the cessation of fallout, all stations that have portable radiac instruments shall monitor and report gamma intensities at time intervals directed by the damage control assistant. This information is used in determining when fallout ceases and in estimating accumulated doses at these locations. The same instrument shall be used for all measurements at a given location during on-station monitoring. The instrument shall be held at the same place and in the same position for each measurement. Beta checks shall also be conducted during on-station monitoring to determine if any contamination has infiltrated into the ship.

NOTE

> Safe stay-time calculations are not valid if they are based on intensity levels measured before the fallout stops. The changes in intensity from that time on are due to radioactive decay and are therefore predictable.

RAPID INTERNAL SURVEY

The rapid internal survey shown in table 11-2 is performed immediately after the cessation of fallout to get an indication of the severity of the radiation hazard at specific locations, primarily action stations. Safe stay times for interior vital stations can be calculated based on the rapid internal survey. These locations include vital stations inside the ship and the closest interior points to topside vital stations. The locations to be surveyed shall be designated in the ship's chemical, biological, and radiological (CBR) defense bill. They should be precisely identified and marked to ensure uniformity among measurements taken at different times. Survey routes can be preprinted using the format provided in and as enclosures to the CBR defense bill.

RAPID EXTERNAL SURVEY

The rapid external survey (table 11-3), sometimes referred to as the gross external survey, is conducted after the rapid internal survey to obtain more precise radiation levels at topside vital stations and at contaminated areas that are irradiating internal vital stations. As in the rapid internal survey, the focus is on getting an accurate measurement quickly at action stations and expeditiously reporting the results. Monitors do not take time to localize or mark hot spots. The team leader shall wear a self-reading pocket dosimeter on his outer clothing. Each monitoring team shall be given a predetermined route and a safe stay time based on the highest estimated topside intensity. Large masses of material, such as superstructure, boats, and aircraft, act as shields for gamma radiation from hot spots and should be used when planning routes for protection from hot spots.

SUPPLEMENTARY SURVEYS

Supplementary surveys (survey sheet shown in table 11-4) are conducted to confirm or revise stay time calculations. They may also be ordered to localize hot spots for decontamination. Supplementary surveys of interior spaces shall include beta monitoring to detect intrusion of contamination. These checks shall be scheduled as needed for individual vital stations or other locations based on the following:

1. Completion of decontamination or air purge.
2. Dosimeter measurements that are at a variance with predicted doses.
3. Watch section rotation.

DETAILED SURVEYS

In a detailed survey, accuracy is more important than speed. Monitors shall proceed slowly and carefully. A detailed survey of the entire exterior is required before arrival at a repair facility if industrial decontamination has been ordered. The commanding officer may order a detailed survey at any time if the tactical situation permits. He can order a ship-wide detailed survey or limit it to specific areas in which relatively high radiation levels have been found. A detailed survey is recommended for any area in which measured dosages exceed predicted levels by more than 25 percent.

An example of a detailed survey form is provided in table 11-5. The grid map method is used to record results of this survey. The grid map is formed by dividing the ship into grid squares measuring 1 square yard. Each square is surveyed in the center at waist height. The preparation of detailed survey forms is not required unless the ship is ordered to an industrial facility and a detailed survey is directed.

Table 11-2. Sample Rapid Internal Survey Form

SHIP:	USS JEFFERSON	DATE:	
TYPE SURVEY:	Rapid Internal	MONITOR:	
ROUTE NUMBER:	2	INSTRUMENT TYPE:	
SHEET NUMBER:	1 of 1	INSTRUMENT SERIAL:	
EXIT:	N/A	REENTRY:	N/A

NUMBER	AREA/OBJECT	TIME	METER READING/INDICATION		
			POSITION	SHIELD OPEN	SHIELD CLOSED
1	CCA #1		3' above deck, 3' inboard of entrance		
2	DECON STATION #1		3' above deck, 3' aft of entrance		
3	MOUNT 52		3' below red circle on overhead		
4	CIC SUPERVISOR CONSOLE		OPERATOR		
5	BRIDGE RADAR REPEATER		OPERATOR		
6	CAPTAIN'S CHAIR		OPERATOR		
7	HELM		OPERATOR		

INSTRUCTIONS:

1. Routes to be established in advance.
2. Do not record RADIAC measurements in SHIELD OPEN column. Enter either BETA or NO BETA.
3. Time of wipe test is the time measurement is made, not time sample was taken.
4. Do not record a gamma (SHIELD CLOSED) measurement on an uncontrolled wipe test. If there is removable contamination (RC), enter RC. If there is none, enter NO RC. Do not record a beta (SHIELD OPEN) measurement on either type of wipe test, only RC or NO RC.
5. POSITION column notations indicate location at which measurement is taken: 3' ABOVE DECK to indicate waist height area monitoring; OPERATOR to indicate normal watchstander position at waist height; CONTROLLED WIPE TEST and UNCONTROLLED WIPE TEST to indicate wipe samples.
6. Readings may fluctuate as RADIAC instrument is rotated through various orientations at the same position. Always record highest measurement obtained.
7. Leave at least two blank rows to record hot spots along survey route.

Table 11-3. Sample Rapid External Survey Form

SHIP: USS JEFFERSON COUNTY TYPE SURVEY: Rapid External ROUTE NUMBER: 3 SHEET NUMBER: 1 of 1 EXIT: Door 02-60-4, Port Side 02 Level Aft of Bridge	DATE: MONITOR: INSTRUMENT TYPE: INSTRUMENT SERIAL: REENTRY: Door 1-110-5, Main Deck Stbd Side Entrance to Decon #2

NUMBER	AREA/OBJECT	TIME	METER READING/INDICATION		
			POSITION	SHIELD OPEN	SHIELD CLOSED
1	Port Bridge Wing		3' above deck, 3' outboard of door		
2	Port Gyro Repeater		Uncontrolled Wipe Test		
3	Flying Bridge		3' above deck, centerline		
4	Gyro Repeater on Flying Bridge		Uncontrolled Wipe Test		
5	Machine Gun		Operator		
			Uncontrolled Wipe Test		
6	Stbd Bridge Wing		3' above deck, 3' outboard of door		

INSTRUCTIONS:

1. Routes to be established in advance.
2. Do not record RADIAC measurements in SHIELD OPEN column. Enter either BETA or NO BETA.
3. Time of wipe test is the time measurement is made, not time sample was taken.
4. Do not record a gamma (SHIELD CLOSED) measurement on an uncontrolled wipe test. If there is removable contamination (RC), enter RC. If there is none, enter NO RC. Do not record a beta (SHIELD OPEN) measurement on either type of wipe test, only RC or NO RC.
5. POSITION column notations indicate location at which measurement is taken: 3' ABOVE DECK to indicate waist height area monitoring; OPERATOR to indicate normal watchstander position at waist height; CONTROLLED WIPE TEST and UNCONTROLLED WIPE TEST to indicate wipe samples.
6. Readings may fluctuate as RADIAC instrument is rotated through various orientations at the same position. Always record highest measurement obtained.
7. Leave at least two blank rows to record hot spots along survey route.

Table 11-4. Sample Supplementary Survey Form

SHIP: USS THOMAS TYPE SURVEY: Supplementary Survey ROUTE NUMBER: 1 SHEET NUMBER: 1 of 2 EXIT:	DATE: MONITOR: INSTRUMENT TYPE: INSTRUMENT SERIAL: REENTRY:

NUMBER	AREA/OBJECT	TIME	METER READING/INDICATION		
			POSITION	SHIELD OPEN	SHIELD CLOSED
1	Crew's Mess Galley Compt. 2-90-2		3' above deck, highest reading in compt.		
2	Crew's Mess Scullery Compt. 2-90-2		3' above deck, highest reading in compt.		
3	Crew's Mess Dining Area Compt. 2-70-2		3' above deck, highest reading in compt.		
4	Crew's Berthing Compt. 3-110-0		3' above deck, highest reading in compt.		
5	Crew's Head Compt. 3-110-1		3' above deck, highest reading in compt.		
6	Crew's Head (Decon 2) Compt. 1-120-2		3' above deck, highest reading in compt.		
7	Crew's Head (Decon 2) Compt. 1-120-2		Controlled Wipe Test, shower controls		

INSTRUCTIONS:
1. Routes to be established in advance.
2. Do not record RADIAC measurements in SHIELD OPEN column. Enter either BETA or NO BETA.
3. Time of wipe test is the time measurement is made, not time sample was taken.
4. Do not record a gamma (SHIELD CLOSED) measurement on an uncontrolled wipe test. If there is removable contamination (RC), enter RC. If there is none, enter NO RC. Do not record a beta (SHIELD OPEN) measurement on either type of wipe test, only RC or NO RC.
5. POSITION column notations indicate location at which measurement is taken: 3' ABOVE DECK to indicate waist height area monitoring; OPERATOR to indicate normal watchstander position at waist height; CONTROLLED WIPE TEST and UNCONTROLLED WIPE TEST to indicate wipe samples.
6. Readings may fluctuate as RADIAC instrument is rotated through various orientations at the same position. Always record highest measurement obtained.
7. Leave at least two blank rows to record hot spots along survey route.

Table 11-5. Sample Detailed Survey Form

SHIP: USS BROWN TYPE SURVEY: Detailed Survey ROUTE NUMBER: 1 SHEET NUMBER: 1 of 10 EXIT: Entrance to Decon #1 Door 1-40-4	DATE: MONITOR: INSTRUMENT TYPE: INSTRUMENT SERIAL: REENTRY: Entrance to Decon #1 Door 1-40-4

NUMBER	AREA/OBJECT	TIME	METER READING/INDICATION		
			POSITION	SHIELD OPEN	SHIELD CLOSED
1	Foc'sle		Frame 1 Centerline		
2	Foc'sle		Frame 2 Port Side		
3	Foc'sle		Frame 2 Stbd Side		
4	Foc'sle		Frame 3 Port Side		
5	Foc'sle		Frame 3 Centerline		
6	Foc'sle		Frame 3 Stbd Side		
7	Anchor Windlass		Controlled Wipe Test		

INSTRUCTIONS:

1. Routes to be established in advance.
2. Do not record RADIAC measurements in SHIELD OPEN column. Enter either BETA or NO BETA.
3. Time of wipe test is the time measurement is made, not time sample was taken.
4. Do not record a gamma (SHIELD CLOSED) measurement on an uncontrolled wipe test. If there is removable contamination (RC), enter RC. If there is none, enter NO RC. Do not record a beta (SHIELD OPEN) measurement on either type of wipe test, only RC or NO RC.
5. POSITION column notations indicate location at which measurement is taken: 3' ABOVE DECK to indicate waist height area monitoring; OPERATOR to indicate normal watchstander position at waist height; CONTROLLED WIPE TEST and UNCONTROLLED WIPE TEST to indicate wipe samples.
6. Readings may fluctuate as RADIAC instrument is rotated through various orientations at the same position. Always record highest measurement obtained.
7. Leave at least two blank rows to record hot spots along survey route.

REVIEW QUESTIONS

Q7. When is on-station monitoring conducted?

1. After cessation of fallout to report gamma intensities
2. Before cessation of fallout to report gamma intensities
3. After cessation of fallout to report alpha contamination
4. Before cessation of fallout to report alpha contamination

Q8. Which survey is sometimes referred to as the gross external survey?

1. Rapid external survey
2. Extensive external survey
3. Basic external survey
4. Precise external survey

Q9. Which of the following terms best describes a type of survey that is recommended for any area in which measured radiation dosages exceed predicted levels by more than 25 percent?

1. *Simple survey*
2. *Intensive survey*
3. *Detailed survey*
4. *Advanced survey*

RADIOLOGICAL EXPOSURE CONTROL

Learning Objective: Recall the different types of exposure control.

Exposure control is the actions required to minimize the spread of contamination to personnel and the shipboard environment. The objective is to limit the total dose received by individuals from both internal and external sources and to minimize the transfer of contamination into the interior of the ship. Onboard your ship you will have a chemical, biological, and radiological (CBR) defense bill, which will have routes, used to minimize and control exposure. Other means of exposure control are protective shielding, ready shelter and deep shelter, which will be described in the following paragraphs.

PROTECTIVE SHIELDING

Protective shielding is one method of defense against nuclear radiation. The tremendous penetrating power of gamma rays makes it difficult to provide enough shielding to protect personnel from gamma rays. However, the structure of the ship provides some protection. The main materials likely to provide shielding aboard ship are steel plating, piping, machinery, water, fuel oil, and perhaps wood. Shielding materials at shore facilities also include concrete and earth.

The amount of shielding required to stop gamma rays is measured in half-value layer thicknesses or "half-thicknesses," for short. A "half-thickness" is defined as the amount of material necessary to cut down the amount of radiation to one-half of its original value. The half-thickness for each material is different. For example, a concrete shield about 6 inches thick or an earth shield about 7 1/2 inches thick will cut the gamma radiation in half. Suppose that you are in a place where the gamma radiation exposure is 400 roentgens. If you are behind a half-value layer thickness at the time, you will receive a dose of 200 roentgens. Now suppose you are standing behind two shields, each of which is a half-thickness. The 400 roentgens of gamma radiation is reduced to 200 roentgens by the first half-thickness and then to 100 roentgens by the second half-thickness. With each additional half-thickness shield, you reduce the remaining gamma radiation by half. Remember that these thicknesses do not stop gamma radiation completely; instead, each cuts it in half. In a nuclear attack, one half-thickness of steel or concrete might be enough shield to keep you from getting a lethal dose of gamma radiation.

The estimated half-thicknesses of some materials are shown below. Note that initial radiation is more penetrating than residual radiation and requires a larger thickness to reduce the radiation to one-half of its original value. These materials are listed in the order of their effectiveness as shields against gamma radiation.

MATERIAL	INITIAL	RESIDUAL
Steel	1.5 inches	0.7 inch
Concrete	6.0 inches	2.2 inches
Earth	7.5 inches	3.3 inches
Water	13.0 inches	4.8 inches
Wood	23.0 inches	8.8 inches

READY SHELTER

If the ship is warned enough in advance, personnel topside shall be ordered to ready shelter before the arrival of the base surge or fallout. Taking ready shelter is both a contamination avoidance measure and a radiation mitigation technique. The locations are generally not deep enough within the ship's structure to result in much reduction of gamma radiation. However, alpha and beta radiation cannot penetrate into the ship.

DEEP SHELTER

Deep shelter locations are compartments in the innermost parts of the ship. Because of distances and the structural material between these compartments, the gamma exposure rate is significantly lower. All except essential personnel at the most vital stations are sent to deep shelter to minimize exposure to initial radiation. Each ship shall designate deep shelter for each battle station in the ship's CBR defense bill.

REVIEW QUESTIONS

Q10. A "half-thickness" is defined as the amount of material necessary to cut down the amount of radiation to one-half of its original value.

1. True
2. False

Q11. The objective of exposure control is to limit the total dose received by individuals from both internal and external sources and to minimize the transfer of contamination into the interior of the ship.

1. True
2. False

Q12. Exposure rate to gamma radiation is significantly lower in deep shelter locations because of distances and the structural material between compartments.

1. True
2. False

DECONTAMINATION

Learning Objective: Recall requirements for personnel in execution of the decontamination process and the basic design of the two types of decontamination stations.

Decontamination of a ship's environment and personnel is essential to the recovery of the ship. Radiological decontamination is the physical removal of the contamination that results from a nuclear weapon detonation. Much of it can be removed easily with soap and water or by brushing or using a sticky surface such as masking tape. The contaminant that remains must be removed either by abrasion (vigorous scrubbing) or by chemical means. The latter method includes using solvents other than water, such as a degreasing hand cleaner. This section establishes a technical basis and describes procedures for shipboard decontamination of personnel, clothing, and tools that have been exposed to radiological fallout. Every possible situation cannot be covered in this text. General guidance is provided that can be applied to a variety of ship arrangements. Detailed information on this subject can be found in chapter 5 of *Naval Ships' Technical Manual* (*NSTM*), chapter 070.

GOOD HYGIENE AND HOUSEKEEPING

Personal sanitation and general housekeeping are very important after a ship has been exposed to fallout. It is extremely difficult to keep all contamination out of the interior of the ship. The ship is not airtight and, unless it has a collective protection system, some airborne particles will enter either through the ventilation system, through accesses, or through leaks. Monitoring and decontamination techniques are not perfect and some contamination will be allowed in on personnel who have been topside. However, the hazard can be minimized simply by preventing it from building up. Maintaining clean conditions in living and working spaces is one part of the solution. The other is personal cleanliness. A simple practice such as washing one's hands before eating will reduce the ingestion of contamination.

DECONTAMINATION PROCESS

All personnel exposed to the weather while a ship is receiving fallout from a nuclear detonation shall reenter through a decontamination station or a contamination control area (CCA). Those who must perform duties topside after the deposition of fallout has ceased are considered to be potentially contaminated. They may be required to reenter through a decontamination station or CCA, depending on the intensity of the radiation from the fallout remaining and its location on the ship. The basic procedures in the decontamination process are the same for all ships. Variations from ship to ship are due to differences in the design and location of decontamination stations.

The basic functions are as follows:

1. Gross decontamination of portable equipment and outer garments
2. Monitoring, removal, and disposal of outer garments
3. Monitoring, removal, and disposal of inner clothing
4. Decontamination of inner clothing
5. Body cleansing
6. Recording accumulated exposure

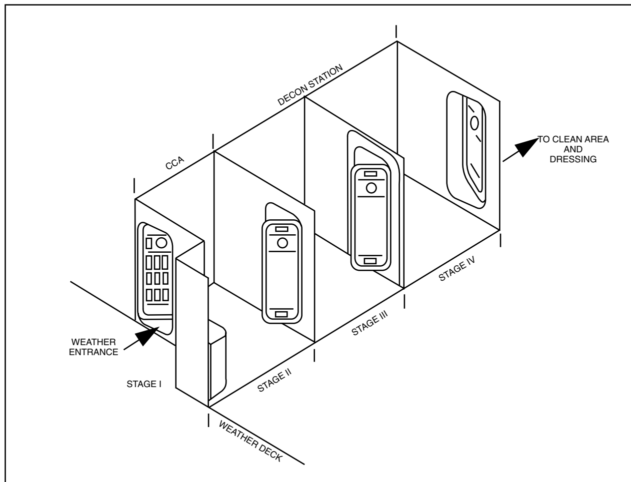
For detailed information on this subject, refer to *NSTM*, chapter 070.

SHIPBOARD DECONTAMINATION INSTALLATIONS

The two types of decontamination stations are as follows:

1. CONVENTIONAL DECON STATIONS. Stations that are not associated with a Collective Protection System (CPS) are referred to as conventional decontamination (decon) stations. Specific washrooms and showers designated in the ship's plans are set up for this purpose when needed.

2. CPS DECONTAMINATION STATION. Ships that have a Collective Protection System (CPS) (fig. 11-8) with Total Protection (TP) zones have a dedicated four-compartment decon station with access to the weatherdeck in each TP zone. This type of facility is referred to as a CPS decontamination station. There are differences in the extent of CPS coverage on different classes or flights of ships and even among ships of the same class or flight. It is possible for a ship with partial CPS coverage to have both CPS and conventional decon stations. For further information refer to *NSTM*, chapter 070.



	CHEMICAL/BIOLOGICAL	RADIOLOGICAL
STAGE I	REMOVAL OF OUTER CLOTHING (WET WEATHER GEAR), BATTLE DRESS ITEMS AND FLIGHT DECK SAFETY EQUIPMENT GROSS DECON OF MASK, BOOTS AND GLOVES	GROSS DECON OF OUTER CLOTHING, BATTLE DRESS ITEMS AND PORTABLE EQUIPMENT
STAGE II	REMOVAL OF CPE MEDICAL CHECK	ENTRANCE MONITORING TO ASSES EFFECTIVENESS OF GROSS DECON OUTER CLOTHING MONITORING AND REMOVAL
STAGE III	REMOVAL OF INNER CLOTHING	INNER CLOTHING MONITORING AND REMOVAL (IF NECESSARY)
STAGE IV	SHOWERING	BODY CLEANSING OF "HOT SPOTS" AND SHOWERING (IF NECESSARY)
	← REDRESSING →	← REDRESSING →

DCf1108

Figure 11-8. CCA/decontamination station for CPS-equipped ships.

REVIEW QUESTIONS

Q13. Radiological decontamination is the physical removal of the contamination that results from a nuclear weapon detonation.

1. True
2. False

Q14. What simple hygiene practice reduces the ingestion of contamination?

1. Washing hands
2. Shower frequently
3. Brush teeth
4. Comb hair

SUMMARY

In this chapter, you have been introduced to RADIAC instruments, radiological surveys, radiological exposure control, and personnel decontamination and shipboard decontamination installations. You will need a good understanding of the radiac instruments since you will use them in the performance of your duties if you are assigned to the radiological monitoring team. When you conduct Planned Maintenance System on the radiac instruments, look them over and review the technical manuals supplied with the instruments. Discuss your repair party chemical, biological, and radiological assignments with your Leading Petty Officer so that you can relate the information presented in this chapter to your actual assignments. Review the various sections of this chapter as necessary until you are familiar with them.

REVIEW ANSWERS

A1. Nuclear radiation cannot be detected by any of the five senses. **(1) True**

A2. Which of the following is NOT a performance function of a radiac device. **(4) Detect neutron and X-ray radiation**

A3. The AN/PDR-43 unit has three-meter scales. **(1) True**

A4. What is the maximum amount of time the AN/PDR-65 will operate on fully charged batteries? **(2) 20 hours**

A5. The DT-60/PD is a gamma radiation dosimeter with a usable range of 10 to 600R. **(1) True**

A6. No hand-held radiac available for military use will measure both radiation intensity and dose. **(1) True**

A7. When is on-station monitoring conducted? **(2) Before cessation of fallout to report gamma intensities**

A8. Which survey is sometimes referred to as the gross external survey? **(1) Rapid external survey**

A9. Which of the following terms best describes a type of survey that is recommended for any area in which measured radiation dosages exceed predicted levels by more than 25 percent? **(3)** ***Detailed survey***

A10. A "half-thickness" is defined as the amount of material necessary to cut down the amount of radiation to one-half of its original value. **(1) True**

A11. The objective of exposure control is to limit the total dose received by individuals from both internal and external sources and to minimize the transfer of contamination into the interior of the ship. **(1) True**

A12. Exposure rate to gamma radiation is significantly lower in deep shelter locations because of distances and the structural material between compartments. **(1) True**

A13. Radiological decontamination is the physical removal of the contamination that results from a nuclear weapon detonation. **(1) True**

A14. What simple hygiene practice reduces the ingestion of contamination? **(1) Washing hands**