FM 3–15

FIELD MANUAL

NUCLEAR ACCIDENT CONTAMINATION CONTROL

HEADQUARTERS, DEPARTMENT OF THE ARMY
NOVEMBER 1975

WARNING

Movement of any amount of plutonium by air is prohibited. Radiac check and calibration sources containing plutonium will not be moved by air. Medical items for individual patients are exempt.

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No. 3-15

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *28 November 1975*

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*This manual supersedes FM 3-15, 17 June 1966, including all changes.

CHAPTER 1

INTRODUCTION

1–1. Purpose

This manual provides guidance for training, equipping, and utilizing emergency teams for nuclear accident/incident radiological contamination control. Specific guidance is provided for CBR alpha and radiological control (RADCON) teams, but the general principles presented apply to all special teams and personnel concerned with nuclear accident/incident control (NAIC). An Alpha team is normally one of the emergency teams that respond in the event of a nuclear accident or incident. A radiological emergency medical team (REMT) is available to advise on and assist in the management of personnel who may have been subjected to significant internal or external exposures of ionizing radiation (AR 40–13). Explosive ordnance disposal (EOD) unit operations for NAIC are specified in FM 9–15.

1–2. Scope

a. This manual covers procedures and techniques for limiting radiation hazards resulting from nuclear accidents and incidents and the control procedures applicable to relatively small areas that contain hazardous levels of radiological contamination. It describes procedures for detecting, identifying, measuring, controlling, and decontaminating radiological contamination and specifies the levels of radiological contamination that are significant both during recovery operations and after decontamination at a nuclear accident/incident site. TM 3–220 and TM 5–225 outline the procedures that are applicable to large areas of radiological contamination.

b. This manual is designed primarily for peacetime operations. It has limited applicability in wartime in a nontactical environment. Alpha contamination is not considered to be militarily significant.

1–3. Comments or Changes

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded direct to Commander, US Army Ordnance Center and School, ATTN: ATSL–CTD–DT–D, Aberdeen Proving Ground, MD 21005.

CHAPTER 2

RESPONSIBILITIES

2-1. General

a. Responsibilities for nuclear accident/incident control are established by AR 50-5. The Joint Nuclear Accident Coordinating Center (JNACC) is a combined Defense Nuclear Agency (DNA) and Energy Research and Development Administration (ERDA)* centralized agency for exchanging and maintaining information pertaining to radiological assistance capabilities and coordinating assistance activities, when called upon, in connection with accidents involving radioactive materials. This coordinating center is located at Field Command, Defense Nuclear Agency, (FCDNA) Kirtland Air Force Base, Albuquerque, NM. The JNACC maintains a continuous watch for emergencies, utilizing the FCDNA staff duty officer, and can be reached by calling Area Code 505, telephone number 264-8279 (AUTOVON 964-8279). JANACC maintains current information on the location and capability of specialized DOD and ERDA teams capable of responding to accidents involving nuclear weapons. All Federal and State agencies may request assistance from JUNACC.

b. The service or agency in physical possession of nuclear material when an accident occurs will have primary command NAIC responsibility at the scene, except for those accidents occurring on a DOD or ERDA installation (the service commanding the installation has NAIC responsibilities) or for those accidents which become domestic emergencies [United States Army Forces Command (FORSCOM) will assume primary command NAIC responsibility for the Department of the Army].

c. The commander of the military installation or ERDA facility nearest the accident will, within the limits of his capability, assume control of emergency operations and will take any necessary action. He will remain in control until a representative of the service or agency responsible for the nuclear material relieves him.

2-2. On-Scene Commander (OSC)

When the OSC, normally a general or flag officer, arrives at the accident or incident scene, he commands all emergency forces and directs all operations at the scene, including but not limited to—

a. Security, safeguarding and disposition of all classified material involved.

b. Surveys to determine actual and potential hazards.

c. Actions to minimize the hazardous effect of a nuclear weapon accident.

d. Requests for required assistance.

e. Reports.

f. Public information.

g. Control and logistic support of observers and other authorized personnel.

h. Claims.

i. Requests to local intelligence units for counterintelligence inspections and surveys.

j. Relations with local civilian groups.

k. Communications between the accident or incident site and higher headquarters.

2-3. Nuclear Accident and Incident Control Officer (NAICO)

A NAICO, normally field grade, is designated by the commander responsible for NAIC to represent him at the scene of a nuclear weapon accident or significant nuclear weapon incident and to act as the designated representative of the OSC when he is not present at the site of the accident or incident. Each NAICO will be qualified by experience or training to command and coordinate the activities associated with NAIC. The NAICO and his staff will respond as soon as possible after notification of a nuclear weapons accident or significant incident. The NAICO will be responsible for the duties listed in paragraph 5 above until the arrival of the OSC.

2-4. Chemical, Biological, and Radiological (CBR) Officer

Major commands and agencies with an NAIC responsibility will provide a staff CBR officer to advise on radiological problems and the requirement for a RADCON team.

*Formerly AEC.

2–5. Alpha Teams

Major commands and agencies with an NAIC responsibility will organize, train, equip, and position enough alpha teams to insure adequate coverage of their areas or activities (chap 5). The Army Materiel Command (AMC) establishes local alpha teams at AMC nuclear weapons storage and maintenance facilities.

2–6. Radiological Control (RADCON) Teams

RADCON teams are capable of performing detailed radiological surveys and providing professional advice in control and decontamination measures at the scene of a nuclear weapon accident or incident (chap 6). The Commander, AMC, provides RADCON teams as prescribed in AR 50–5.

2–7. NAIC SOP

A command plan or SOP for nuclear accident/incident control shall be prepared by organizations that are involved with nuclear weapons or NAIC emergency operations. This plan or SOP must provide plans for rehearsals and tests (AR 50–5).

CHAPTER 3

PROTECTION FROM NUCLEAR WEAPON HAZARDS

3–1. General

a. The hazards surrounding nuclear weapons and special nuclear material are similar to those of conventional weapons and dangerous chemicals. However, somewhat more emphasis on usage protection is necessary because of the potential long-term effect on persons and denial of property if contaminated.

b. Nuclear weapons are designed to survive all but the most severe abnormal environments and are "one-point" safe. A nuclear yield can be produced only upon functioning of the weapon in the normal sequence of arming and firing. In an abnormal situation, the high explosive and radioactive material can be hazardous. The precautions outlined in this section are based on experience gained during actual "accident" situations and the nature of the hazardous material which may be encountered.

3–2. Hazards

a. High Explosives. The high explosive contained in most nuclear weapons constitutes a major hazard in a nuclear weapon accident. If the high explosive becomes ignited, it will either burn rapidly or on some occasions explode. Nonnuclear detonation and fires that occur during shipment or storage of nuclear weapons must be handled in accordance with the provisions of TM 5–315 and TB 385–2.

b. Radioactive Nuclear Weapon Materials.

(1) *Plutonium.* Plutonium is a heavy metal which when first processed looks like stainless steel, but which rapidly oxidizes to a characteristic brownish-black color. When associated with a fire, plutonium may burn, producing radioactive plutonium oxide particles. Detonation of the high-explosive component may pulverize plutonium into minute, invisible particles that are dispersed in smoke and dust which can cause contamination over a large area. If the high explosive burns instead of detonating, the amount of plutonium dispersed into the atmosphere is insignificant and represents a serious health hazard only in the immediate area of burning at the accident site and in the smoke cloud. Plutonium in a pulverized form is flammable. Deposits of pulverized plutonium produc when an accident occurs may be resuspended natural forces, such as the wind, or by perso nel, vehicles, and low-flying aircraft operati in the area. Air sampling is necessary to pro erly evaluate the hazard caused by airbor radioactive particles. The plutonium referred throughout this manual is plutonium–239 (a breviated ^{239}Pu). The primary radiation haza from ^{239}Pu is due to alpha particle emission. ^{239} emits a 5.15-meV alpha particle that trav about 4 centimeters in air.

(*a*) The primary hazard caused plutonium results from inhalation of the alph emitting particles. The actual amount plutonium or plutonium oxide that is absorb through the lungs is the critical factor. This extremely difficult to estimate because abso tion is dependent on many factors, i.e., parti size, solubility of the material, particle densi and breathing rate of the individual. Most of t plutonium that enters the bloodstream is de sited in bone and the liver. A few months aft exposure, 80 to 90 percent of absorb plutonium will be found in the skeleton. Skele deposition may produce bone diseases (includi cancer) many years later. It is assumed that a airborne plutonium from a high-explosive de nation or fire will have settled by the time t Alpha or RADCON team arrives at the scen Alpha contamination would be on the ground on debris. If there is a possibility that plutoni is still airborne at the accident, a high-filtrati respirator (equivalent to the M17-series fi protective mask, or better) should be worn un any cloud or smoke has settled or drifted aw from the area, or until the possibility of blowi dust or smoke has passed, or until air sampli equipment has been operated and indicates le than 50 cpm/m^3 airborne alpha contaminati Table 3–1 is a guide to the type of respirato protection recommended in areas whe plutonium contamination, either airborne or the ground or on debris, is encountered. (T personnel hazard would be inhalation of t plutonium resuspended in the air by E team/Alpha team/RADCON team activ around the weapon and handling of contaminated parts.)

(*b*) The entry of plutonium into the bloodstream through deep puncture wounds also presents a serious hazard even though it is a slow process. Thorough cleaning and bandaging will normally prevent this entry. Absorption of plutonium through the unbroken skin or from shallow wounds is of negligible concern.

(2) *Uranium.* Uranium may be in the form of uranium-235 or uranium-238 (abbreviated ^{235}U or. ^{235}U). When first processed, uranium looks like stainless steel, but it slowly oxidizes to a golden color and then to a characteristic blue-black or black color. Like plutonium, uranium is a heavy metal, is an alpha emitter, is flammable in a finely divided powder, and sparks when scratched with a metallic object. Uranium particles, which are dispersed and enter the body in the same manner as plutonium, are less severe radiological health hazards. The principal known hazard with uranium particles is heavy metal poisoning. Safety precautions applicable to plutonium are also applicable to uranium.

c. Fission Products. Should a nuclear weapon or device involved in an accident result in a partial nuclear yield, there will be a beta-gamma radiation hazard from the fission products as well as an alpha radiation hazard from unfissioned uranium or plutonium. Because of the short range and low penetrating ability of beta particles, they constitute a limited external hazard, but may produce skin burns if beta emitters remain in contact with the skin.

Table 3–1. Recommended Respiratory Protection Against Airborne Alpha Contamination [1]

Note. Prior to initial entry, personnel will always don high-filtration respirator (M17-series mask or equivalent).

Permissible level (cpm/m^3)	Protection
0 to 50	No respiratory protection.
50 to 50,000	High-filtration respirator at least 99.9 percent effective (M17-series mask or equivalent).
Greater than 50,000	Self-contained breathing apparatus.

[1] The guide to EOD personnel is contained in FM 9–15.

3–3. Radiation Hazards

The significant hazardous levels of ground radiological contamination that have been established for a nuclear accident are—

a. Beta-gamma radiation—10 millirad per hour (10 mrad/hr). It should be emphasized that large-scale beta-gamma contamination will result only from a nuclear, or partial nuclear, detonation. Since nuclear weapons are designed to minimize the probability of an accidental significant nuclear detonation, this occurrence will be extremely rare. Low-energy gamma radiation is emitted during plutonium decay. Therefore, localized hot spot readings of several mrad/hr may be present even though a nuclear yield has not occurred.

b. Alpha radiation—1,000 micrograms of plutonium-239 per square meter (1,000 μg $^{239}Pu/m^2$). However, any concentration higher than 10 micrograms of plutonium–239 per square meter for alpha radiation may produce a serious resuspension problem because the plutonium may become airborne (or aerosolized). When alpha contamination is detected, the contaminant is assumed to be ^{239}Pu because it constitutes the greatest internal hazard. Measures taken to control ^{239}Pu contamination are more than adequate for contamination by ^{235}U. These levels are arbitrary lines to establish contours and do not indicate contours of maximum permissible contamination. A radioactive hazard will exist outside these lines.

3–4. Operational Protective Measures

a. All personnel entering an accident area will wear respiratory protective equipment until it has been positively determined that this type of protection is not needed. The site should be approached from upwind, and visible concentrations of dust or smoke should be avoided. Table 1 is a guide to the type of respiratory protection recommended against airborne alpha contamination. This table is based on the hazard from plutonium contamination, so if only uranium is present, a greater margin of safety is provided since uranium is not as hazardous as plutonium.

b. Eating, drinking, chewing, and smoking will not be permitted in the contaminated area. Smoking material and foodstuff will not be carried into the contaminated area.

c. Cuts or breaks in the skin should be protected to minimize the posibility of internal contamination.

d. Disposable items such as coveralls, hood, gloves, and boot covers should be worn to avoid personnel contamination and facilitate decontamination procedures. Military uniforms and civilian clothing are generally not satisfactory for these operations, but may be worn in emergency if additional precautions are taken to protect the body (para 9–3*d*, *e*).

e. To prevent large-scale resuspension of hazardous material, all aircraft, particularly rotary-wing types, should stay clear of the contaminated area. Motor vehicles required to travel in the contaminated area must move slowly to avoid resuspension of hazardous material.

f. Entry into and exit from the area of suspected contamination will be through the established control points at the contamination co trol station (para 9–4). Surfaces in the area (d bris, shrubbery, puddles, and the like) which a possibly contaminated should be avoided whe possible.

g. Prior to entry into the area of suspecte contamination, personnel should insure th their clothing and equipment are properly pr pared (para 9–3). A final check of clothing ar equipment will be made by the monitor at th entry point (para 9–4).

CHAPTER 4

CONTROL OF A NUCLEAR ACCIDENT SITE

4–1. General

a. Immediate military control of a nuclear accident site will be established by the nearest military commander pending arrival of the OSC/NAICO or the representative of the service or agency having physical possession of the weapon. Control requirements will vary according to the magnitude of effects from the nuclear accident. Commanders of troop units should comply with the procedures stipulated herein to the extent commensurate with their capabilities prior to arrival of trained specialists. Some emergency actions may be performed by civilian personnel pending arrival of emergency forces from military installations. These actions may include—

(1) Rescue, first aid, and evacuation of injured personnel.

(2) Firefighting, but only to prevent further personnel injury.

(3) Notification of the nearest military installation and appropriate civilian agencies.

(4) Control of movement of civilians and assistance in traffic control by the civil law enforcement authorities.

b. Upon arrival at the accident scene, the first actions of the emergency teams must be those necessary to save lives, except that EOD teams must render safe the weapon (FM 9–15). If it is necessary to evacuate contaminated personnel, coordination must be accomplished to assure acceptance of such patients at hospitals. Such coordination should be accomplished by the supporting emergency medical team or REMT. A medical tag such as shown in figure 4–1 should accompany each contaminated person. These tags should be stockpiled by NAIC units.

c. The emergency teams discussed in this manual do not have sufficient personnel assigned to provide control of the accident site and still accomplish their primary missions. The OSC/NAICO will request additional support personnel from the nearest military installation to augment the emergency teams and to provide security and control of the area.

d. Security of the nuclear weapon is essential. The provost marshall advises on physical security matters and traffic control. He coordinates the use of security forces with representatives of State and local governments as appropriate. The physical security team assists in securing the area and controlling traffic.

4–2. Control Measures

Upon arrival at the scene of the accident, the OSC/NAICO or the commander of the nearest military installation or his representative will establish a control point to coordinate all activities directed toward control of the area. Measures required for control of the hazardous area include those for control of personnel and for control of contamination.

a. Area Control. The size and shape of any area requiring control measures will depend upon the nature of the accident and upon meteorological and terrain conditions. Since the contamination may extend for considerable distances, the area that must be evacuated will be determined by the OSC/NAICO after evaluating monitoring and surveying reports. Pending detection of alpha contamination or measurement of significant beta-gamma contamination, the following guides will be used to mark the exclusion area (zone of hazard created by the presence of the high explosives in the weapon):

(1) Coordinate with EOD personnel to ascertain the area of hazard from fragmentation should a detonation of the nuclear weapon high explosive component occur. This area can be used for initial contamination control procedures prior to actual monitoring. However, in the event that EOD personnel have not arrived at the site, the exclusion area for detonation of high explosives will not be less than 610 meters (2,000 feet) in radius.

(2) Extend the exclusion area downwind to distances dependent on varying ambient surface wind velocities. The minimum recommended distances for air sampler placement are as shown in table 8–4.

b. Personnel Control. Personnel in support of the control and recovery activities will be dis-

NOTICE

TO MEDICAL AUTHORITIES

1 - RADIOACTIVE CONTAMINATION MAY BE PRESENT.

2 - USE ALL POSSIBLE CARE TO PREVENT SPREAD OF CONTAMINATION.

3 - CLEAN WOUNDS VERY THOROUGHLY, DEBRIDEMENT MAY BE ADVISABLE.

4 - MEDICALLY, PATIENT SHOULD BE HANDLED LIKE ANY OTHER CASE.

Figure 4–1. Sample medical tag.

tinctively identified to facilitate control and to expedite recovery operations.

(1) *Control point.* A control point will be established near, but upwind and outside, the exclusion area to minimize radiation exposure to personnel.

(2) *Control stations.* Entry and exit points to the exclusion area will be limited to that number absolutely necessary for control and recovery of the area. Records of entry and exit times of all personnel will be maintained. Those persons not associated with emergency operations will remain outside the exclusion area. Security personnel should enforce personnel control measures prescribed by the OSC/NAICO or the military commander in charge. If an accident occurs outside a military installation, employment of military police must be in conjunction with civilian law enforcement agencies (AR 360–5).

c. Contamination Control. Every effort should be exerted to contain the contamination within a localized area. Personnel and animals should be evacuated from the area suspected of contamination as quickly as possible. Evacuation of personnel and area control may be expedited by use of card handouts such as those shown in figures 4–2 and 4–3. They may be printed on 3- by 5-inch cards, using red lettering. These cards should be stockpiled by the NAIC unit.

(1) Personnel leaving and animals and equipment being removed from any contaminated area will be monitored at a control station to minimize spread of contamination. Movement within a contaminated area should be reduced to a minimum. The safe handling and disposition of contaminated deceased humans and animals will be in accordance with procedures specified by senior radiation protection personnel. Control of civilian personnel and their ani-

E M E R G E N C Y

THIS AREA PROBABLY CONTAINS RADIOACTIVE CONTAMINATION

Follow my directions to the radiation control point where you will be given further instructions.

Figure 4–2. Sample radiation hazard card.

mals in accidents occurring outside of government lands will be done in coordination with civilian authorities.

(2) Controls will be established so that the total dose from all sources of nuclear radiation received by contamination control individuals will not exceed the dose established by Federal regulations (set forth in para 10–4). A film badge, as well as both low-range and high-range self-indicating dosimeters, will be worn by all personnel entering the area. Procedures will be established to prevent the inhalation and ingestion of radioactive particles. These requirements may be waived for emergencies, such as rescue of injured personnel.

(3) Decontamination stations should be lo- cated adjacent to exit control stations so that decontamination can be supervised by the Alpha team or the RADCON team.

(4) Radioactive waste will be controlled an placed in temporary storage pending receipt final disposition instructions from Commande Edgewood Arsenal, ATTN: SAREA–TS–M Aberdeen Proving Ground, MD 21010.

(5) Air sampling stations should be es lished downwind to determine possible airb concentration of radioactivity (para 8–8).

EMERGENCY

THIS AREA PROBABLY CONTAINS RADIOACTIVE CONTAMINATION

Follow my directions to the radiation control point where you will be given further instructions.

Figure 4-2. Sample radiation hazard card.

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(3) Decontamination stations should be located adjacent to exit control stations so that decontamination can be supervised by the Alpha team or the RADCON team.

(4) Radioactive waste will be controlled and placed in temporary storage pending receipt of final disposition instructions from Commander, Edgewood Arsenal, ATTN: SAREA-TS-MM, Aberdeen Proving Ground, MD 21010.

(5) Air sampling stations should be established downwind to determine possible airborne concentration of radioactivity (para 8-8).

TRAFFIC CONTROL INSTRUCTIONS

THIS ACCIDENT MAY HAVE CAUSED RADIOACTIVE CONTAMINATION IN THE LOCAL AREA. YOU ARE REQUESTED TO DETOUR AROUND THIS AREA. IF YOU PROCEED AT YOUR OWN RISK:

1. Keep all windows and vents closed.
2. Proceed without stopping.
3. Wash vehicle thoroughly at first opportunity.

Figure 4-3. Sample traffic control card.

CHAPTER 5

ALPHA TEAM

5-1. General

As used in this manual, Alpha team will be understood to refer to a CBR team with the additional capability and responsibility for alpha and beta-gamma monitoring.

5-2. Mission

The mission of the Alpha team is to—

a. Detect, identify, and report radiological contamination resulting from an accident.

b. Report the presence of radiological contamination immediately upon detection to the OSC/NAICO or, in his absence, to the senior officer present.

c. Mark the 1,000 μg $^{239}Pu/m^2$ contour line if alpha radiation is detected (para 10-2).

d. Mark the 10 mrad/hr contour line if beta-gamma radiation is detected (para 10-2).

e. Mark the exclusion perimeter. If both alpha and beta-gamma radiation are detected, the exclusion perimeter will be a combination of contours as determined in *c* and *d* above, using the contour farthest from the accident site.

f. Provide security for any nuclear weapon components if the team is first to arrive at a nuclear accident site.

g. Perform other duties as assigned by the OSC/NAICO.

5-3. Organization

The Alpha team should consist of one officer and four enlisted men, all qualified in the detection, identification, and measurement of radiation and having a general knowledge of the decontamination and health physics aspects of radioactivity. Two trained monitors and two alternates per Alpha team is the minimum requirement. At least two of the enlisted men should additionally be qualified driver/radio operators.

a. The team leader will coordinate the activities of the Alpha team with other emergency teams at the accident site and furnish advice on radiological monitoring and survey procedures and emergency decontamination measures for personnel (pending arrival of the RADCON team).

b. All team members will be qualified to perform alpha, beta, and gamma radiation monitoring and surveying.

c. All team members will be qualified to install and operate air samplers

d. All team members will have a minimum security clearance of SECRET.

5-4. Utilization

a. Major commands with a nuclear accident/incident control responsibility will organize, train, and position sufficient Alpha teams so as to insure adequate coverage of their area. During each Army shipment involving a complete nuclear weapon or nuclear component, an Alpha team will be on standby status in the major command area of responsibility. The most expeditious mode of transportation will be immediately available to move the team to an accident site. Once an alerted Alpha team has been committed, other teams from the major command area should be placed on standby to be used for backup or in support of other Army nuclear weapon shipments.

b. Upon arriving at the accident site, the team will report immediately to the OSC/NAICO or his respresentative and then coordinate with other emergency teams present. In the event the Alpha team is the first to arrive at the accident site, the team leader will assume responsibility for directing emergency actions until properly relieved.

c. To insure adequate control of contamination at the accident site, a contamination control station (CCS) is established prior to or during the initial entry and is situated upwind of the accident site. It must be in an area that is free of radioactive contamination. A detailed discussion of CCS operations is contained in paragraph 9-4. The OSC/NAICO will establish the CCS, and Alpha team and REMT personnel will normally assist in CCS operations.

d. After coordination with other emergency teams, the Alpha team will monitor for radiological contamination. Detection of any radiation above normal background will be reported immediately. The Alpha team will then conspicuously mark the location of the 10 mrad/hr beta-gamma contour line and/or the 1,000 μg $^{239}Pu/m^2$ level for alpha contamination, and record the data. Unit conversion factors necessary in evaluating alpha contamination are contained in chapter 8. Contamination markers (fig 10-1) attached to stakes should be used to mark the contaminated area. The Alpha team does not go beyond these contour lines. The contaminated area will be controlled and a RADCON team will be requested by the OSC/NAICO. The Alpha team will remain at the site to furnish advice and special assistance to the OSC/NAICO. Upon arrival of the RADCON team, the Alpha team, if directed by the OSC/NAICO, will assist the RADCON team.

e. The Alpha team or other teams as designated by the OSC/NAICO must ascertain the names and locations of all individuals and identify any animals that were in the immediate vicinity of the accident for possible legal and medical reasons. All personnel and animals should be monitored, decontaminated if necessary, and referred to the RADCON team or REMT personnel for further tests. When monitoring civilian personnel, monitors should be careful not to alarm or frighten them unnecessarily. Control of the area to preclude reentry of unauthorized personnel or animals should be established.

f. Relationships with news media personnel will be as prescribed in AR 360-5 and AR 360-43 and as specified by the OSC or PIO advisor.

CHAPTER 6

RADIOLOGICAL CONTROL (RADCON) TEAM

6–1. General

A RADCON team is a special radiological team that is organized to provide technical assistance and advice to the OSC/NAICO in radiological emergencies.

6–2. Mission

The mission of the RADCON team is to—

a. Perform a detailed radiological survey for alpha and beta-gamma radiation (para 10–1 through 10–4).

b. Control and supervise waste disposal measures (para 12–1 through 12–4).

c. Provide health physics services.

d. Control and supervise radiological safety services.

e. Supervise and provide technical advice for decontamination operations (para 11–1 through 11–4).

f. Provide technical advice to the OSC/NAICO on all radiological aspects of the accident.

g. Supervise and provide technical advice for the control and containment of the radiological contamination at an accident site (para 9–1 through 9–4).

6–3. Organization

The RADCON team will consist of a minimum of a team leader, a qualified health physicist, and eight individuals who have particular specialties or skills identified in *a* through *h* below. In addition, they will be qualified in air sampling and in monitoring for alpha, beta, and gamma radiation. All team members will have a minimum security clearance of SECRET and be authorized access to RESTRICTED DATA and CRITICAL NUCLEAR WEAPON DESIGN INFORMATION.

a. The team leader should be a Nuclear Effects Engineer (MOS 7330) or an equally qualified civilian. He must have a detailed knowledge of nuclear weapon accident potentials and the associated hazards. He should be qualified in radiological safety and nuclear emergency team operations. The team leader will coordinate the activities of the RADCON team with other emergency teams and the OSC/NAICO at the accident site. He is responsible for the training and readiness of the team at all times, to include supervising the members when engaged in team support activities. He should keep abreast of the latest developments in military and commercial radiacmeters and other support equipment. *The team leader, together with a medical representative, will certify that the contamination has been reduced to an acceptable level (para 11–7 and 11–8) for release of the area after operations have been completed.*

b. The health physicist must be trained in the protection of personnel from the hazardous effects of radiation. He must have a knowledge of shielding requirements, dose calculations, maximum permissible limits of exposure, and sampling and evaluation techniques for air, water, and ground contamination. He will provide all dosimetry services for the team and other personnel as directed by the team leader. He will maintain complete exposure records as outlined in AR 40–14 and Title 10, Code of Federal Regulations, Parts 19 and 20. The health physicist will advise the team leader on health physics matters and interpretation of the data obtained.

c. The laboratory technician must be trained in radiochemistry laboratory procedures and techniques and qualified to perform radiological laboratory analyses of samples, to include quantitative alpha determinations. He will be qualified to obtain air, water, and surface samples and to evaluate the data obtained. He will maintain all necessary laboratory data and records related to samples and analyses. In addition, he will be capable of acting as assistant to the health physicist when directed by the team leader.

d. The equipment specialist will be qualified to operate, check, and make limited field repairs on all of the types of radiacmeters and air samplers used by the team. His functions will be to store, control, issue, and maintain all of the electronic equipment in possession of the team

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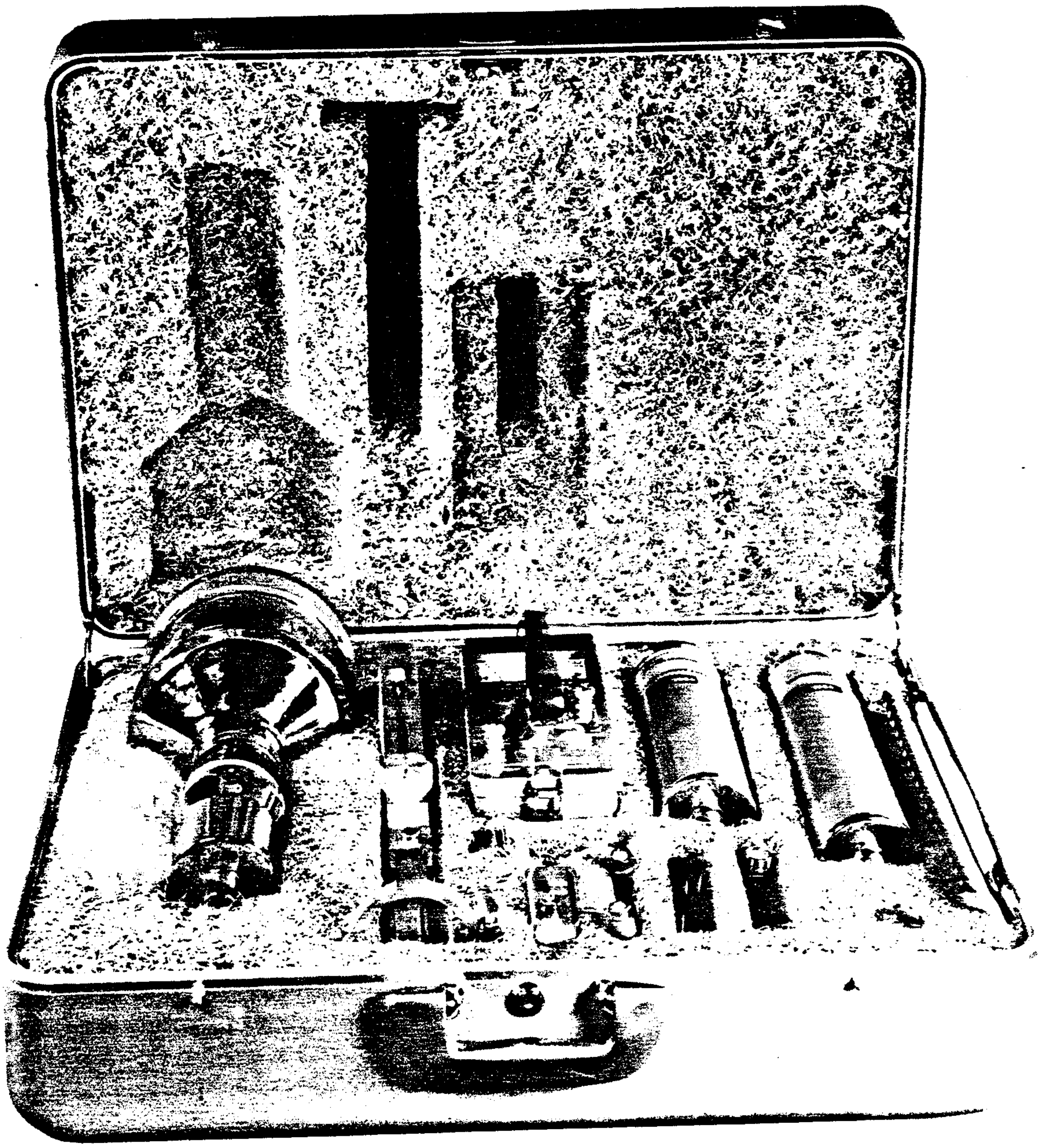
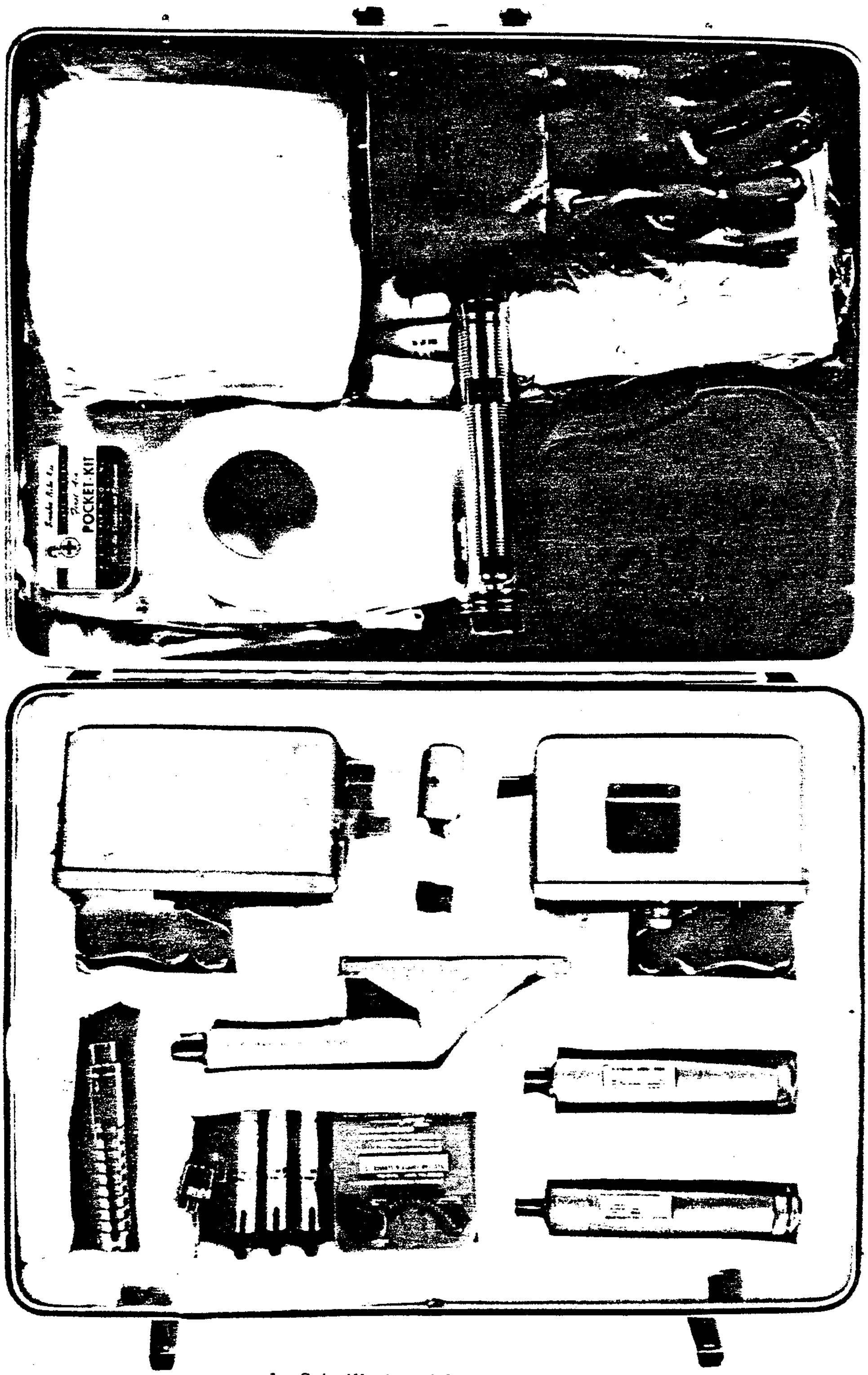


1. FIDLER probe (5 in. x 2 mm NaI crystal)
2. PRM-5 pulse rate meter (scintillation alpha counter)
3. PG-2 probe (2 in. x 2 mm NaI crystal)
4. SPA-3 probe (2 in. x 2 in. NaI crystal)
5. Carrying handle for FIDLER probe

Figure 6-1(1). Sample flyaway kit components—radiac equipment.

at the accident site. Further, he will check the functioning of the radiac equipment, using appropriate check sources and generators. He will maintain all records on the equipment in accordance with TM 38-750, TB 43-180, and other pertinent publications. In addition, the equipment specialist will maintain two complete flyaway kits (fig 6-1) ready to move at all times.

e. The decontamination specialist will be qualified to advise the team leader on all aspects



1. Scintillation alpha counter
2. Millipore filter counters
3. Proportional counter (AC-3 probe)

Figure 6–1(2). Sample flyaway kit components—radiac equipment and protective clothing.

Figure 6-2. Use of special vacuum cleaner for area decontamination.

Figure 6-3. Monitor with FIDLER probe and PRM-5 pulse-rate meter (components of flyaway kit).

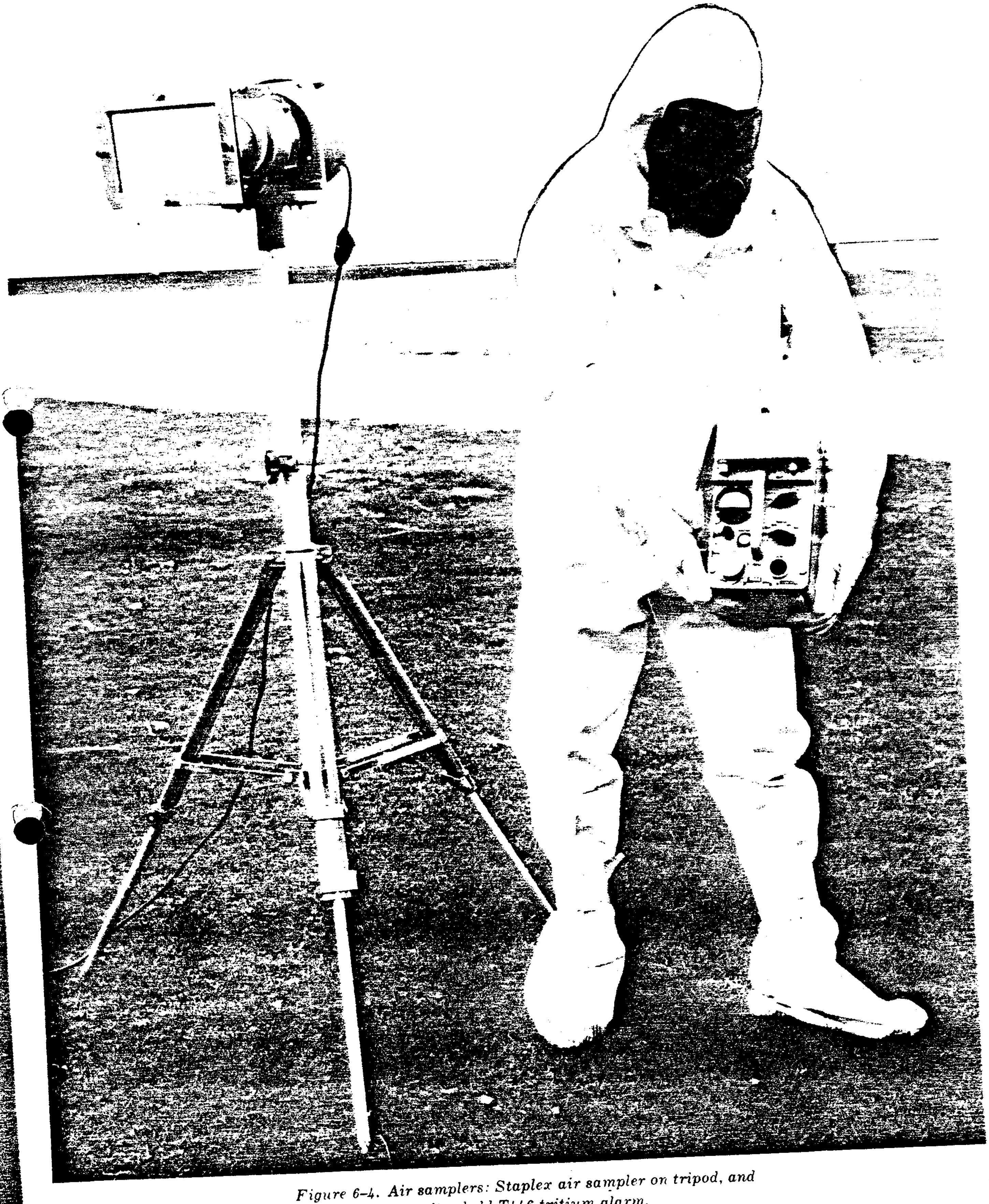


Figure 6-4. Air samplers: Staplex air sampler on tripod, and monitor-held T446 tritium alarm.

of radiological decontamination of personnel, equipment, facilities, and large areas (fig 6–2). He will have a working knowledge of shielding requirements, waste disposal procedures, and shipping requirements for radioactive waste. *He will supervise the establishment and operation of the personnel and equipment decontamination stations.*

f. The two monitors will be qualified to perform survey and monitoring (fig 6–3), to install and operate air samplers (fig 6–4), to take other samples as required, and to assist in the monitoring duties at the contamination control station (para 9–4). In addition, they will be proficient in decontamination procedures and will assist the decontamination specialist when directed by the team leader.

6–4. Equipment

Table 6–1 is a list of the minimum quantities of equipment recommended to accomplish the assigned missions of the Alpha and RADCON teams. For extended operations, both teams will require additional support. The OSC/NAICO will request this support from the nearest military installation. The request may include, but is not limited to, messing facilities, quartering facilities, lighting equipment, power generators, engineer equipment, communication equipment, and additional personnel. The Alpha and RADCON team equipment lists should be kept as small as possible consistent with accomplishment of their missions. Both teams must maintain a high degree of mobility so that they may be responsive to any radiological emergency.

WARNING

Movement of any amount of plutonium by air is prohibited. Radiac check and calibration sources containing plutonium will not be moved by air. Medical items for individual patients are exempt.

Table 6–1. Suggested Equipment for Alpha and RADCON Teams [1]

Item No.	LIN [2]	Item	Quantity: Alpha team	Quantity: RADCON team	Reference [3]
		A. DETECTION AND IDENTIFICATION EQUIPMENT			
1.	Q19750	Radiac set: [3] AN/PDR–60	3	4	AR 310–34
2.	Q19339	Radiac set: [4] AN/PDR–27	4	4	AR 310–34
3.	Q21483	Radiacmeter: IM–174A/PD	3	4	AR 310–34
4.	—	Tritium monitor (Atomic model TSM–91–B or T–446, or equiv)	0	1	—
5.	—	Repair parts and extra batteries for radiac instruments	as rqr	as rqr	—
6.	—	Air sampler, high vol, 110V AC, w/filter holders, filters, and power source (Example: Staplex TF1A–27)	0	[5] 4	—
7.	50080N	Air sampler, high vol, 24V DC, w/filter holders, filters, and power source (Example: Staplex TF1A–4)	3	[5] 4	CTA 50–900
8.	—	Tripod mount for air samplers	3	4	—
9.	—	Gamma radiacmeter (Eberline model PAC–6A, or equiv)	0	2	—
10.	—	Flyaway kit [6]	0	2	—
11.	—	Scintillation alpha counter (Eberline model SAC–3, or equiv)	0	1	—
12.	—	Millipore filter counter (Eberline model SPA–1, or equiv)	0	1	—
13.	—	Analyzer, multichannel	0	1	—
14.	—	Anemometer, ML–433A/PM (NSN 6660–00–663–8090)	0	1	—
15.	C74570	Calibrator, radiac, AN/UDM–6	1	1	CTA 50–900
		B. DOSIMETRY AND HEALTH PHYSICS EQUIPMENT			
16.	Q20798	Radiacmeter: IM–9/PD [7]	1 per team.	—	AR 310–34
17.	Q21209	Radiacmeter: IM–147/PD [7]	2 per member. —	2 per member. 8 per team.	
18.	Q20935	Radiacmeter: IM–93A/UD [7]	2 per member. 1 per team.	2 per member.	AR 310–34
19.	—	Pocket dosimeter (0–5 rad), self-indicating	1 per member.	1 per member.	AR 310–34
20.	E00533	Charger, radiac detector, PP–1578A/PD	0 2 per team. 1 per 4 dosimeters	30 per team. 2 per team. 1 per 4 dosimeters	—

See footnotes below table.

Table 6-1. Suggested Equipment for Alpha and RADCON Teams [1]—Continued.

Item No.	LIN [2]	Item	Quantity: Alpha team	Quantity: RADCON team	Reference [2]
B. DOSIMETRY AND HEALTH PHYSICS EQUIPMENT—Continued					
			(NTE 5 per unit)	(NTE 5 per unit)	AR 310-34
21.	—	Film badge (beta-gamma) [7]	1 per member.	2 per member.	—
22.	—	Film badge (neutron)	0	1 per member.	—
23.	—	Replacement film for film badges	as rqr.	as rqr.	—
24.	—	Nose and surface swipe kit consisting of:	1	1	—
		Cloth swipes — 2,000 ea			
		Applicator, wood, cotton tip (1/12 in. x 6 in.) — 1,000 ea			
		Test tube, 10 ml (for use w/cotton swipes) — 50 ea			
		Plastic envelope (½ in. x 3 in. for use w/cotton swipes) — 1,000 ea			
25.	—	Soil sampling kit consisting of:	0	1	—
		Broom, whisk, straw, 8 in. — 2 ea			
		Knife, putty, 1 in. x 6 in. — 2 ea			
		Bottle, wide-mouth, screw-cap, 210 ml — 20 ea			
26.	—	Polyethylene bottle, 1 liter cap	0	50	—
27.	—	Replacement parts for sampling equipment	as rqr.	as rqr.	—
C. COMMUNICATIONS EQUIPMENT [8]					
28.	W38299	Radio set: AN/PRC-77, or similar type	0	1	TOE/TDA
29.	R29799	Receiver set, radio: AN/PRR-9	3	4	TOE/TDA
30.	X17820	Transmitter set, radio: AN/PRT-4	3	4	TOE/TDA
31.	—	Spare batteries for radios in use	as rqr.	as rqr.	—
D. ELECTRONIC REPAIR EQUIPMENT					
32.	—	Tool kit, electronic repair	0	1	—
33.	—	Meter, volt-ohm	0	1	—
34.	—	Repair parts, electronic equip kit	0	1	—
35.	—	Replacement parts for instruments	0	as rqr.	—
E. MARKING EQUIPMENT					
36.	—	Tape, textile, white, herringbone weave (Engineer tape), ¾ in. wide, feet	5,000	3,000	—
37.	—	Radiation hazard marking signs w/stakes and maul	as rqr.	as rqr.	—
38.	—	Grease pencils, assorted colors	as rqr.	as rqr.	—
F. DECONTAMINATION EQUIPMENT					
39.	—	Personnel decon kit (soap, towels, brushes, brooms, etc.)	1 per member	1 per member	—
40.	—	Portable vacuum cleaner, American Vacuum Cleaner Co, ARCO model 52 or equiv, w/attchment kit 505A w/abso-filter unit 5C1802	0	1	—
41.	—	Masking tape, 1-, 2-, and 3-in. widths	as rqr.	as rqr.	—
G. PROTECTIVE EQUIPMENT					
42.	80598N	Boot, nuclear radiation protective	1 pr per member.	1 pr per member.	CTA 50-900
43.	81475N	Coveralls, safety, industrial, plastic, disposable	2 per member.	2 per member.	CTA 50-900
44.	F33046	Coveralls, safety, industrial, cotton sateen, white	2 per member.	3 per member.	CTA 50-900
45.	J66420	Gloves, cloth: work type	1 per member.	3 per member.	CTA 50-900

See footnotes below table.

Table 6-1. *Suggested Equipment for Alpha and RADCON Teams* [1]*—Continued.*

Item No.	LIN [2]	Item	Quantity: Alpha team	Quantity: RADCON team	Reference [3]
		G. PROTECTIVE EQUIPMENT—Continued			
46.	—	Gloves, surgeon's, pr	3 per member.	6 per member.	—
47.	—	Cap, surgeon's	2 per member.	3 per member.	—
48.	—	Hood, cotton cloth	1 per member.	3 per member.	—
49.	M11895	Mask, CBR: M17-series, or equiv	1 per member.	2 per member.	AR 310–34
50.	—	Masking tape, 3-in. rolls	as rqr.	as rqr.	—
51.	—	Breathing apparatus, self-contained oxygen generating, M20, or equiv	0	4	—
52.	—	Replacement canisters for oxygen-generating breathing apparatus	0	as rqr.	—
		H. INDIVIDUAL EQUIPMENT [9]			
53.	—	First-aid packet, individual	1 per member.	1 per member.	indiv/unit.
54.	—	Lensatic compass	2	4	unit.
55.	—	Canteen, w/cup	1 per member.	0	indiv/unit.
56.	—	Poncho (or raingear)	1 per member.	1 per member.	indiv/unit.
57.	—	Clipboard	2	8	unit.
58.	—	Flashlight, w/batteries	1 per member.	1 per member.	unit.
59.	—	Entrenching tool	1 per member.	1 per member.	indiv/unit
		I. ADMINISTRATIVE SUPPLIES [10]			
60.	—	Notebook	2	2	unit
61.	—	Roadmaps of areas of responsibility	2	2	—
62.	—	Paper, pencils, blank forms, maps, overlay paper, acetate, press release forms	as rqr.	as rqr.	unit.
63.	—	Camera, still photo	1	1	TOE/TDA
		J. MISCELLANEOUS EQUIPMENT			
64.	—	Plastic bags, large, 30 gal. drum size	10	500	unit.
65.	—	Plastic bags, medium	10	1,000	unit.
66.	—	Plastic bags, small	as rqr.	as rqr.	unit.
67.	—	Binoculars, M13A1, 6 x 30, or equiv	2	2	TOE/TDA
68.	—	Foodlockers	as rqr.	as rqr.	unit.

1. Suggested items of equipment are based on current Basis of Issue (BOI) as indicated in either AR 310–34 or CTA 50–900.
2. Line item numbers and references are provided for nonexpendable equipment suggested for CBR Alpha teams to assist installation commanders in the equipping of these teams. AR 310–34 provides *only* BOI for Alpha team equipment. Authority to requisition this equipment is based on local TOE/MTOE/TDA/MTDA authorizations. Alpha team equipment not listed in local authorization documents must be added in accordance with procedures described in AR 310–49. The Army Authorization Documents System (TAADS). CTA 50–900 provides both BOI and authority to requisition the items listed therein.
3. Radiac set: AN/PDR 60 is currently under consideration for replacement by the AN/PDR 56 set.
4. Models A through H are obsolescent items; models J, L, P, Q, and R are standard.
5. Total of four samplers required. May be a combination compatible with unit power sources.
6. Each AMC-established local Alpha team has two kits.
7. For calculation of dosimeter requirements *only*, the following personnel are considered as "team members": On-scene Commander/NAICO, Alternate NAICO, and firefighters on the scene. Addition of these personnel should result in a minimum requirement for 10 additional dosimeters.
8. For on-site communications only. Depending on the situation and conditions existing between the site and the nearest military installation, the team mission may be expedited by the addition of one AN/VRC–12 or VRC–43 through 49-series radio (or similar type) per Alpha or RADCON team.
9. Personal clothing and sundry requirements should support team members for one week without resupply. Individual and unit clothing and equipment cited herein is for technical mission use. Clothing should be adequate for the terrain and weather in which the teams are employed. Civilian-type clothing and protective gear will be issued to maximum extent for RADCON team.
10. Toll tickets and Bell System and POL credit cards are recommended also, when and where feasible.

6–5. Utilization

a. If a nuclear accident occurs, a RADCON team will be immediately placed on alert status. If required, the services of a RADCON team will be requested by the fastest means of communication available with an IMMEDIATE precedence. Within CONUS, RADCON teams are available upon request of the OSC/NAICO from the Commander, US Army Materiel Command. RADCON team assistance may be requested from the Army Operations Center (AOC), area code 202, 695-0441 (AUTOVON 225-0441), or through the JNACC (para 2-1). Direct requests may be made by message to the Director, USA Ballistics Research Laboratories, Aberdeen Proving Ground, MD, or by telephone to the Chief, Nuclear Vulnerability Branch (VL-BRL-USSA-RDC) area code 301, 671-4431/3027; or AUTOVON 584-4431/3027 during duty hours. After duty hours, call area code 301, 278-4500, or AUTOVON 283-4500 (Staff Duty Officer, Aberdeen Proving Ground). Assistance may be obtained from the FORSCOM Emergency Operations Center, Fort McPherson, GA (area code 404, 752-3222; or AUTOVON 588-3222). Any request for assistance should include as much of the following information as available. (NAIC reporting procedures are contained in AR 50-5.)

(1) Name, location, and telephone number of the person requesting the assistance; i.e., the OSC/NAICO.

(2) Type of accident, such as weapon, reactor, or other. In weapon accidents the proper code name, where applicable, should be given.

(3) Location of the accident site and coordinating instructions for leading the team to the control point, if required.

(4) Type of radiation (alpha, beta, or gamma), extent of area, and levels of contamination if known.

(5) Type of surface involved, such as open field, roadway, or buildings.

(6) In case of accidents involving shipments of radioactive materials, the types of radioisotopes involved, if known.

(7) Location of nearest airfield.

b. Upon receipt of a movement order, the RADCON team will be en route within 4 hours. The team will travel by air or surface transportation, whichever provides the most expeditious means. If the entire team cannot be en route within 4 hours, an advance party consisting of a minimum of the team leader and a health physicist and one monitor will be en route within 4 hours. The remainder of the team, under the command of the assistant team leader, will proceed as soon as possible after the advance party so as to arrive within 24 hours after receipt of the movement order.

c. Upon arrival at the accident site, the team leader will report to the OSC/NAICO for instructions. If not already accomplished by the Alpha team, the RADCON team will determine the degree and extent of radiological contamination. *The RADCON team will secure the names of all individuals and ascertain the identity of any animals involved in the accident and determine their present location. Decontamination of personnel, animals, and equipment will be accomplished within physical limitations. Cleanup and contamination control measures taken by augmentation personnel with equipment obtained from adjacent military installations will be supervised by the RADCON team.* The Alpha team can provide additional specialist assistance if requested. Chapter II contains decontamination details.

CHAPTER 7

RECOMMENDED TRAINING PROGRAM FOR ALPHA AND RADCON TEAMS

7–1. General

The training program recommended for team training is based on the assumption that each member of a team has received individual training at the appropriate service school; therefore, the program is designed to train the members to function as a team. This training should be conducted in conjunction with the training of other emergency teams. Some formal training courses are listed in table 7–1.

7–2. RADCON Team

a. All members must be trained in alpha and beta-gamma monitoring and in sampling techniques to include air sampling.

b. Training to qualify individual team members in their assigned functions will be conducted periodically to insure proficiency. Each member of the team shold be cross-trained in an alternate position whenever possible. See table 7–1 for a listing of formal training courses.

Table 7–1. Formal Training Courses

Team member	Course title, number, and length	Location
NAICO Alpha team	Nuclear Emergency Team Exercise (NETEX) (1 week).	Interservice Nuclear Weapons School, Air Training Command, Kirtland Air Force Base, NM.
OSC (first 2 days only) NAICO	Senior Officers Nuclear Accident Course (SONAC) (4 days).	Do.
RADCON team leader Alpha team leader.	Nuclear Emergency Team Operations (NETOPS) (2 weeks, 4 days).	Do.
Medical personnel	Nuclear Hazards Training Course (NHTC) (4½ days).	Do.
RADCON team leader Health physicist	Radiological Safety, 7K–F3 (3 weeks)	US Army Ordnance Center and School, Aberdeen Proving Ground, MD.
OCS NAICO	EOD Orientation Course (2 days)	Naval School, Explosive Ordnance Disposal, Indian Head, MD.
Alpha team leader NCOIC, Alpha team	CBR Alpha Team Leader, 2E–F31/494–F4 (1 week)	US Army Ordnance Center and School, Aberdeen Proving Ground, MD.

7–3. Alpha Team

a. In addition to the CBR training program, an alpha monitoring course will be presented to designated Alpha teams by their team leaders. A suggested course outline is in table 7–2.

b. See table 3 for a listing of formal training courses appropriate for the Alpha team members.

7–4. Test Alerts

Periodic test alerts are required to determine that individuals are adequately trained in all operational phases. See appropriate Army or major command Nuclear Accident/Incident Control Plan (NAICP) for details.

Table 7–2. Alpha Team Training

Period	Hours	Subject	Scope	References
1	1	Orientation	Definitions of terms and description of appropriate NAICP or FORSCOM basic plan. Discussion of where the team fits into the NAICP and the duties of team members.	AR 50–5; FM 3–15 appropriate NAICP or FORSCOM basic plan.
2	1	Procedures and Protection; Hazards of Alpha Radiation.	Procedures and problems concerning alpha radiation. Protection against hazards. Basic science of alpha radiation.	FM 3–15; TM 5–225; TM 11–6665–221–15.
3	2	Alpha Survey Meters and Survey Techniques.	Familiarization with standard alpha instruments. Characteristics, controls, operation,	Do.

Table 7-2. Alpha Team Training—Continued

Period	Hours	Subject	Scope	References
			nomenclature, use, functioning, and maintenance. Survey techniques.	
4	2	Beta-Gamma Survey Meters and Survey Techniques.	Familiarization with standard beta-gamma instruments. Characteristics, controls, operation, nomenclature, use, functioning, and maintenance. Survey techniques.	TM 11-6665-209-15; TM 11-6665-214-10; TB SIG 226-8.
5	1	Control Procedures and Site Operations.	Procedures for establishment and operation of the hot line, decontamination station, and air sampling stations; data collection procedures.	FM 3-15; TM 5-225; TM 11-6665-221-15.
6	1	Procedures and Protection for Alpha Monitoring.	Procedures and problems concerning the monitoring of alpha radiation. Techniques of alpha monitoring. Protection against hazards; protective clothing and equipment.	Do.

CHAPTER 8
ALPHA MONITORING TECHNIQUES

8-1. General

a. The principal alpha emitters contained in nuclear weapons are uranium (^{235}U, ^{238}U) and plutonium (^{239}Pu). All three easily become airborne and can be inhaled. Plutonium, because of its long half-life and highly energetic emissions, is the most dangerous and presents the greatest internal hazard. Therefore, all measurements of alpha contamination will be considered in terms of plutonium-239.

b. The maximum range in air of alpha particles depends on their energy. Under standard conditions, the maximum range in air of alpha particles from ^{239}Pu is 4 centimeters. Liquids, such as water, and solids, such as paper or animal tissue, will reduce this range by a factor of about a thousand. For example, a ^{239}Pu alpha particle will penetrate only about 0.004 centimeter of paper. Considering these facts, it is apparent that alpha contamination may be exceedingly difficult to detect under some conditions even though the detecting instrument works perfectly.

8-2. Radiac Equipment

a. Alpha Radiacmeters.

(1) *AN/PDR-60 radiac set (containing IM-170/PD radiacmeter).* The AN/PDR-60 radiac set (fig 8-1) contains the IM-170/PD radiacmeter (fig 8-2), which is a portable alpha-measuring and gamma-detecting device utilizing one of the two available external probes and an internal Geiger-Mueller (G-M) detector. For a detailed description, see TM 11-6665-221-15. Using the G-M detector, high energy gamma monitoring is possible up to 2 rad/hr. With the alpha probe (AC-3), the meter can detect up to 2,000,000 cpm. Shields to measure count rate higher than basic instrument count rate are available from the manufacturer. The alpha probe uses a zinc sulfide silver-activated scintillator for measuring alpha in the presence of limited beta and gamma radiation. The alpha probe can be calibrated on all four scales using the AN/UDM-6 radiac calibrator (see TM 3-6665-203-10). The plutonium gamma probe (PG-1) uses a NaI (T1) scintillation crystal for detecting the low energy gamma radiation (17 keV) associated with ^{239}Pu.

(2) *AN/PDR-54 radiac set (containing IM-154/PD radiacmeter).* The IM-154/PD radiacmeter (fig 8-3) is capable of measuring only alpha radiation and detects up to 100,000 cpm. Shields to measure count rate higher than basic instrument count rate are available from the manufacturer. For detailed information, see TM 11-6665-208-15. The AN/PDR-54 set is calibrated by the AN/UDM-6 radiac calibrator (TM 3-6665-203-10) or the AN/UDM-7 radiac calibrator.

(3) *AN/PDR-56E radiac set (containing IM-160E radiacmeter).* The AN/PDR-56E radiac set (fig 8-4) is used to measure alpha radiation up to an intensity of 1,000,000 cpm. The set consists of two principal parts, the IM-160E/PDR-56 radiacmeter and the main probe DT-224A/PDR-56. (The auxiliary probe is the DT-228/PDR-56.) The primary source of power is two 1½-volt batteries. A regulated power supply produces -4 and -10V for the transistor circuits and -1,000V (nominal) for the photomultiplier tube. In addition, the radiacmeter consists of a Schmitt trigger, a buffer inverter and a count rate circuit. The output of this last circuit is measured on the meter or indicated by clicks in the headphones. The probe uses a silver-activated zinc sulfide screen as a scintillator. An alpha particle, with energy greater than the detection threshold (about 3 meV), which is incident to this screen produces a pulse of light. This light pulse is conducted to the photocathode of a photomultiplier tube by a lucite light pipe. This results in the emission of photoelectrons which, due to secondary emission, produce a sufficiently large pulse at the plate of the photomultiplier tube to trigger the Schmitt discriminator via an emitter follower. The meter output is proportional to the intensity of the alpha contamination. This set is calibrated with the AN/UDM-7 radiac calibrator.

b. Beta-Gamma Radiacmeters.

(1) *IM-174/PD, IM-174A/PD, and IM-174B/PD.* These ion chamber instruments measure high dose rates of gamma radiation only.

Figure 8-1(1). AN/PDR-60 radiac set in carrying case.

For detailed instructions, see TM 11-6665-213-12 and TM 11-6665-232-12.

(2) *AN/PDR-27( ) (IM-141/PD).* This Geiger-Mueller instrument is capable of measuring low dose rates of gamma radiation and of detecting beta radiation. For detailed instructions, see TM 11-6665-209-15.

8-3. Monitoring Procedures

a. Beta-Gamma. The monitors will check for the presence of beta-gamma radiation prior to and while monitoring for alpha radiation.

b. Alpha. Several factors are to be considered when using alpha radiacmeters such as the IM-170/PD.

(1) *General.* Alpha radiation is very difficult to detect. This is primarily due to the extremely short range of the emitted alpha particles, about 4 centimeters in air. Alpha instruments must be placed very close, approximately 3 millimeters (1/8 inch), to contaminated surface before they will detect and measure alpha radiation. This makes alpha monitoring a slow, tedious, and physically tiring process. The range of alpha particles is decreased considerably by liquids or solids. A wet surface, resulting from rain, dew on the ground, or from firefighting (a distinct possibility at a nuclear accident site), cannot be monitored successfully using the alpha probe of any instrument. Dust settling over the contaminated area can also prevent a correct reading. The PG-1 probe of the IM-170/PD radiacmeter can be used effectively under these conditions, provided the ambient gamma background

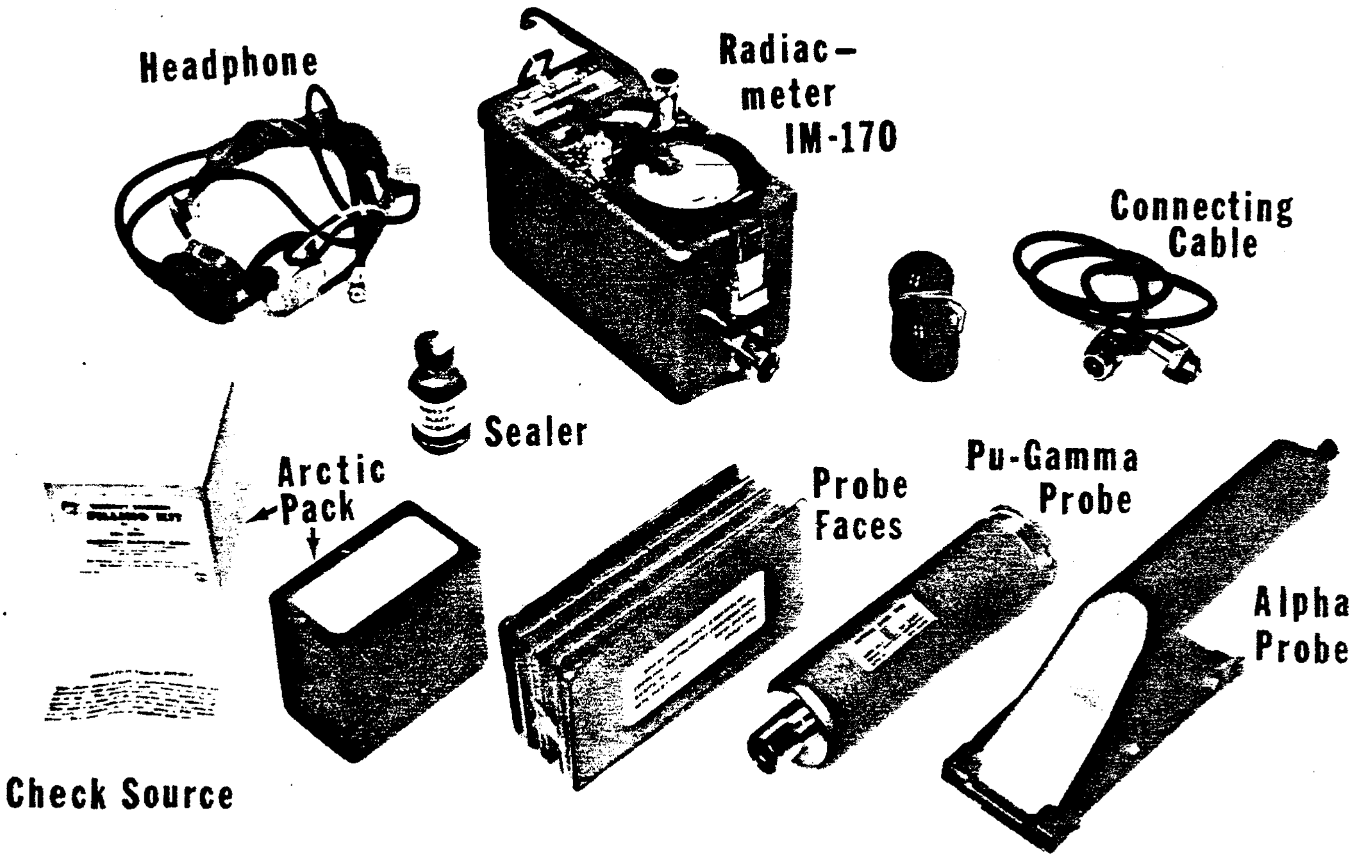


Figure 8-1(2). Components of the AN/PDR-60 radiac set.

is insignificant, to detect the presence of ^{239}Pu, but other means must be used to determine the level of alpha contamination. The PG-1 probe can also be used for rapid hazard area definition under normal conditions. The contaminated surface itself must be considered. On a rough surface such as plowed ground, clothing, or rough concrete, the alpha contamination settles in depressions and crevices in the surface. The alpha particles subsequently emitted are shielded by the surface itself and may not be detected by an instrument no matter how close the instrument is to the surface. Correction factors for various surfaces have been obtained from tests and are discussed in paragraph 8-4.

(2) *Detailed procedure.*

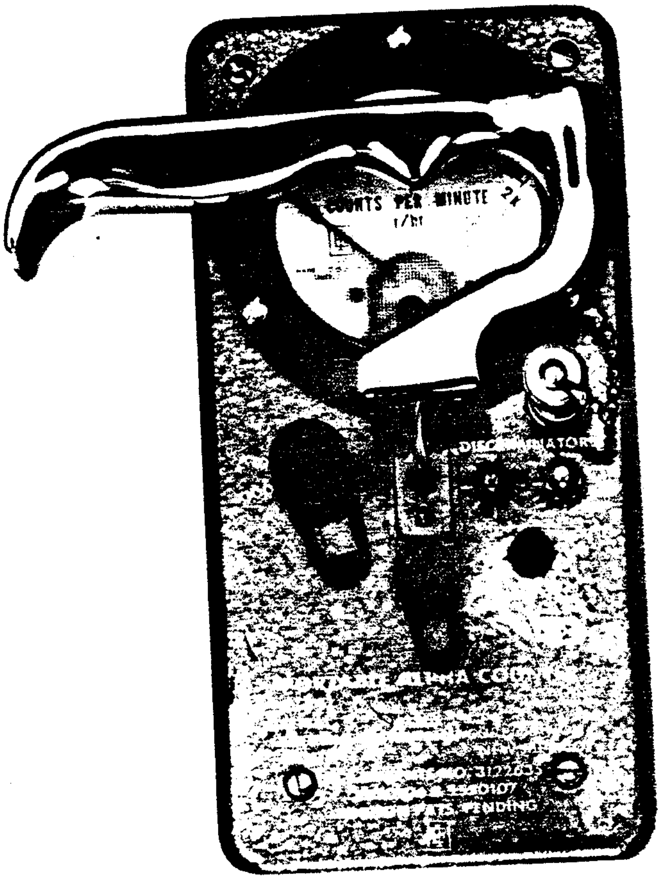
(*a*) To take a reading, the probe should be placed in contact with the surface being monitored.

Caution: The probe face is very thin and extremely fragile. Set the probe down gently and do not place it down on any sharp object, such as grass stubble or rocks, which might puncture the thin window.

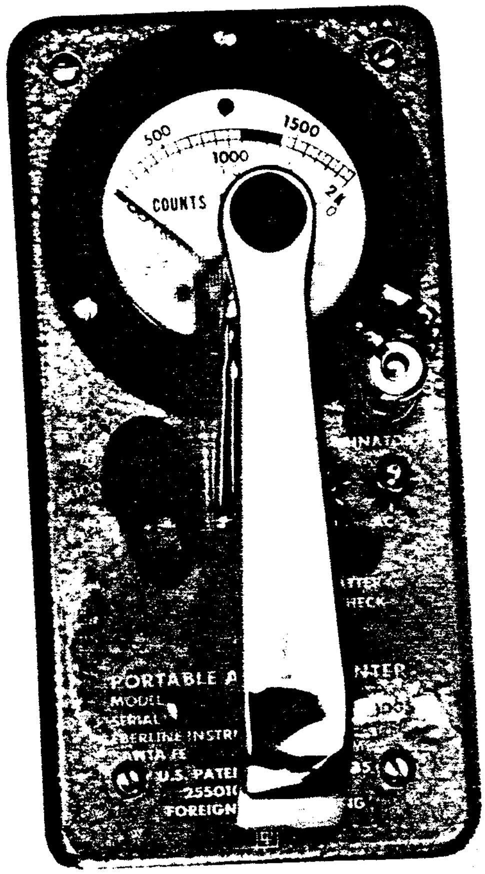
On grassy surfaces, the back of the probe may be used to push the grass aside, and the probe face may be lowered to the surface by a rolling motion of the probe (fig 8-5). Placing the probe on the surface insures consistent results; even though the probe face might become contaminated. In most instances, any contamination will be a small percentage of the total reading and can be either neglected or subtracted from the succeeding surface readings. If the probe contamination reading is large compared to the surface reading, the probe must be decontaminated. Contamination can generally be removed by wiping across the probe face very gently with a damp cloth or gently pouring water from a canteen over the probe face. Water under pressure must never be used for this procedure. If the probe cannot be decontaminated by these methods, the probe face should be changed.

Caution: Unless extreme care is used in decontaminating the probe face, the mylar window may be pierced. Minute pinholes are difficult to find and to patch. (Pinholes may be patched by applying black lacquer to puncture.)

On dry, powdery surfaces where large amounts



(a) Handle displaced



(b) Handle in place

Figure 8-2. IM-170/PD alpha radiacmeter.

of probe contamination would result if the probe touched the surface, a ⅛-inch block may be taped to each end of the probe. This will insure a constant probe height above the surface when readings are taken. This will also reduce the instances of probe puncture. If the blocks are permanently attached to the probe and the instrument calibrated in this configuration, there will be no appreciable decrease in correctness of readings. If the blocks are not permanently attached, the instrument must be recalibrated with the blocks in place or a correction otherwise made.

(*b*) To obtain a representative reading for a particular point, several readings should be taken on and around the point. After each of these readings, the probe should be lifted off the surface and the meter checked to see if any contamination has resulted. If so, the contamination readings must be subtracted from the succeeding reading. Record the highest of these corrected readings as the reading for the point in question.

Note. When using the AN/PDR-60, a delay of 4 to 6 seconds will be encountered before the meter will indicate the correct level of alpha particle emission (cpm).

(*c*) An accuracy figure for any alpha radiacmeter cannot be specified because any measurement will vary considerably, depending on the energy of the emitted alpha particle and the type of surface being monitored. If more than one type of surface is being monitored, the surface type and condition should be included with the meter reading from the point.

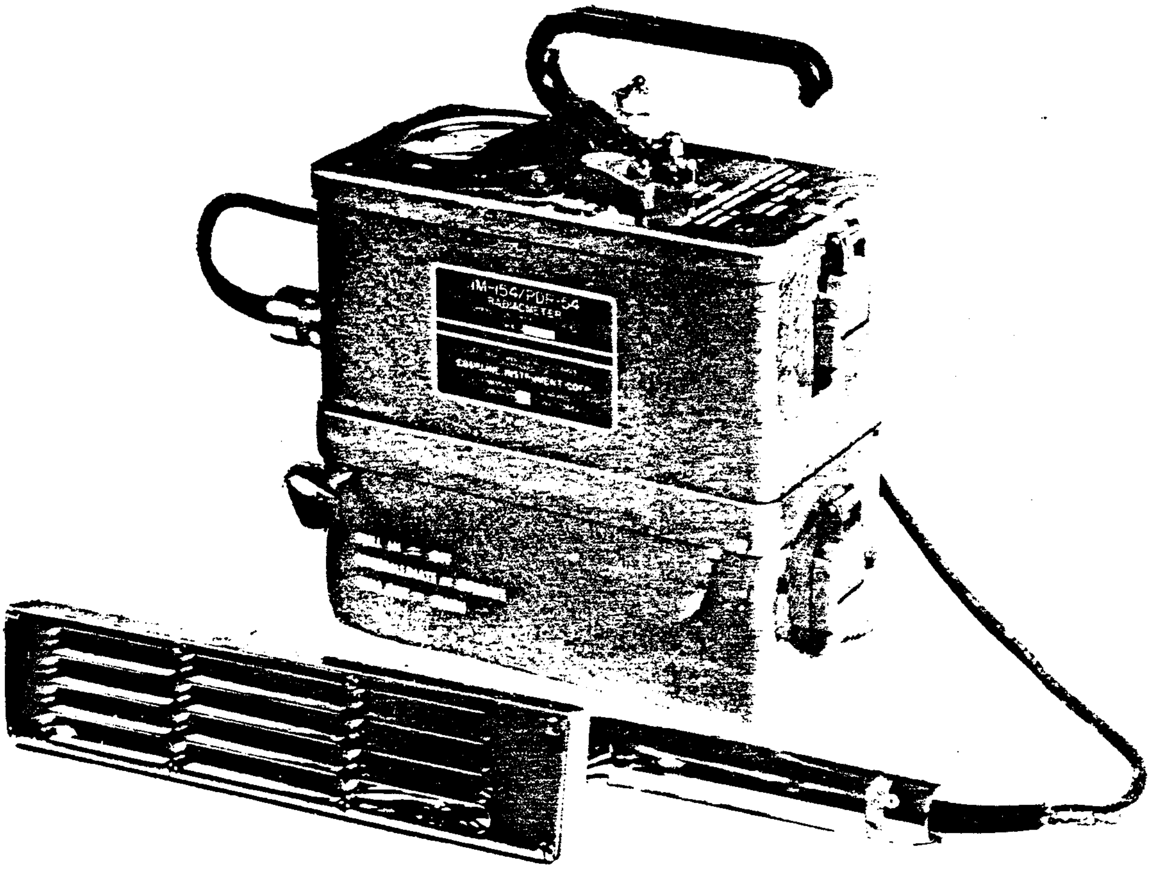


Figure 8-3. IM-154/PDR-54 radiacmeter.

8-4. Conversion of Units

a. In order to establish contamination contours significant to the operation of both the Alpha and RADCON teams, it is necessary to convert indicated meter reading in cpm into micrograms of Plutonium contamination per square meter. This is done using the following formula:

$$\mu g\ {}^{239}Pu/m^2 = \frac{R \times E \times 10^4}{1.4 \times 10^5 \times A} = \frac{R \times E}{14 \times A}, \quad \text{(Equation 1)}$$

where R = radiacmeter reading (cpm),
E = efficiency factor to convert cpm to dpm (disintegrations per minute),
A = effective area of probe in cm^2,
10^4 = factor to convert cm^2 to m^2, and
1.4×10^5 = specific activity of ^{239}Pu (dpm/μg).

The values of E and A are given for each standard radiacmeter in table 8-1.

Table 8-1. Values of E and A for Standard Alpha Radiacmeters

Instrument	Efficiency factor (E)	Effective probe area (cm^2) (A)
IM-170/PD (AN/PDR-60)	2	59
IM-154/PD (AN/PDR-54)	2	61
IM-160E (AN/PDR-56)	1.16	11

b. Equation 1 is derived with the assumption that there will be no sample self-absorption or surface absorption of alpha particles. These assumptions make the equation valid only for very smooth surfaces, such as glass, with the contamination evenly divided over the surface, which seldom occurs in field situations. Equation 1 can be modified for field use by combining the constant factors (E and A) in equation 1 and a surface factor into one overall correction factor. Then:

$$\mu g\ {}^{239}Pu/m^2 = R(CF), \quad \text{(Equation 2)}$$

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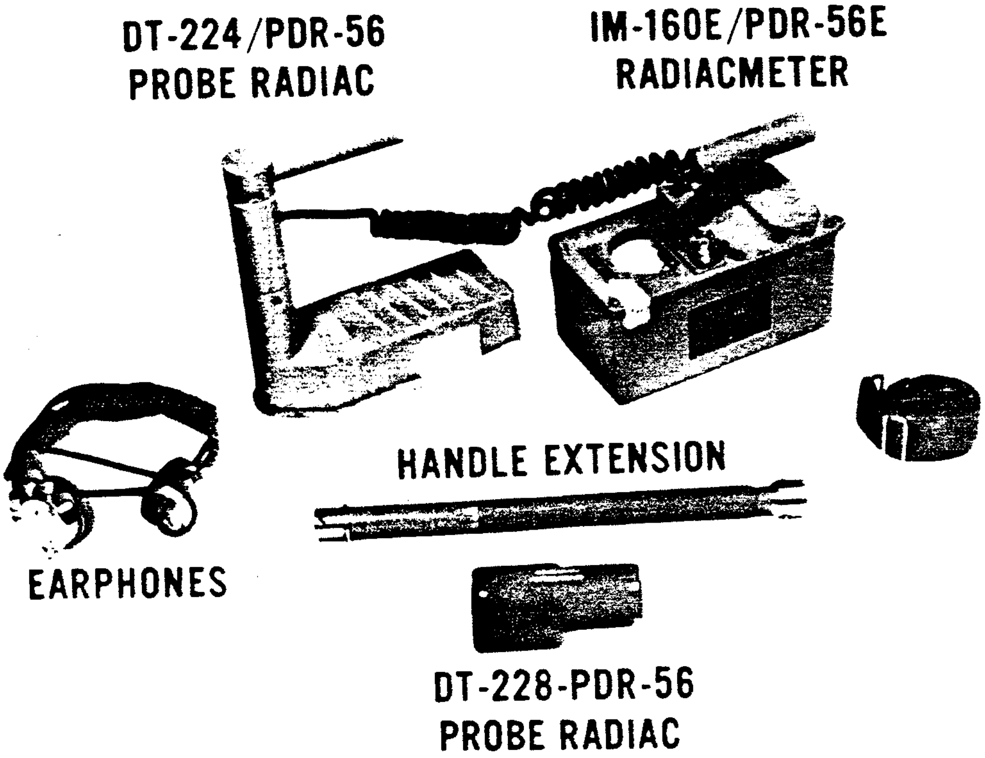

Figure 8-4. Components of the AN/PDR-56E radiac set.

where R = meter reading (cpm),
and
CF = correction factor to convert meter readings into $\mu g\ ^{239}Pu/m^2$.

Correction factors for some common surfaces are given in table 8-2. If the surface being monitored is not listed in table 8-2, use the correction factor for the surface which most nearly approximates the surface being monitored. Occasionally, very rough surfaces will be encountered for which none of the correction factors in table 6 are appropriate. For example, when monitoring on plowed ground with the IM-170/PD radiacmeter, the factor used is approximately ⅛. A reading of 80,000 cpm obtained on plowed ground is equivalent to approximately 10,000 $\mu g\ ^{239}Pu/m^2$. If no appropriate correction factors can be determined, record the meter readings and consult with the RADCON team leader upon his arrival.

Table 8-2. Correction Factors for Some Common Surfaces

Instrument	Correction factor[1] (from meter reading to $\mu g\ ^{239}Pu/m^2$)			
	Concrete	Soil	Plywood	Smooth[2]
IM-170 (AN/PDR-60)	1/200	1/170	1/240	1/400
IM-154 (AN/PDR-54)[3]	1/200	1/170	1/240	1/400
IM-160E (AN/PDR-56)	1/50	1/45	1/60	1/100

[1] Valid for short period of time (within 10 days) after the accident. After this period, weathering will reduce particle density on the surface.
[2] Calculated from equation 1 and safesided.
[3] If either the X20 or X100 shield is used, multiply the answer obtained by 20 or 100, respectively.

c. Table 8-3 gives the converted meter readings for the standard alpha instrument IM-170. This table gives the monitor a quick reference for field use in converting meter readings to $\mu g\ ^{239}Pu/m^2$. The readings given are for even, relatively smooth common surfaces only.

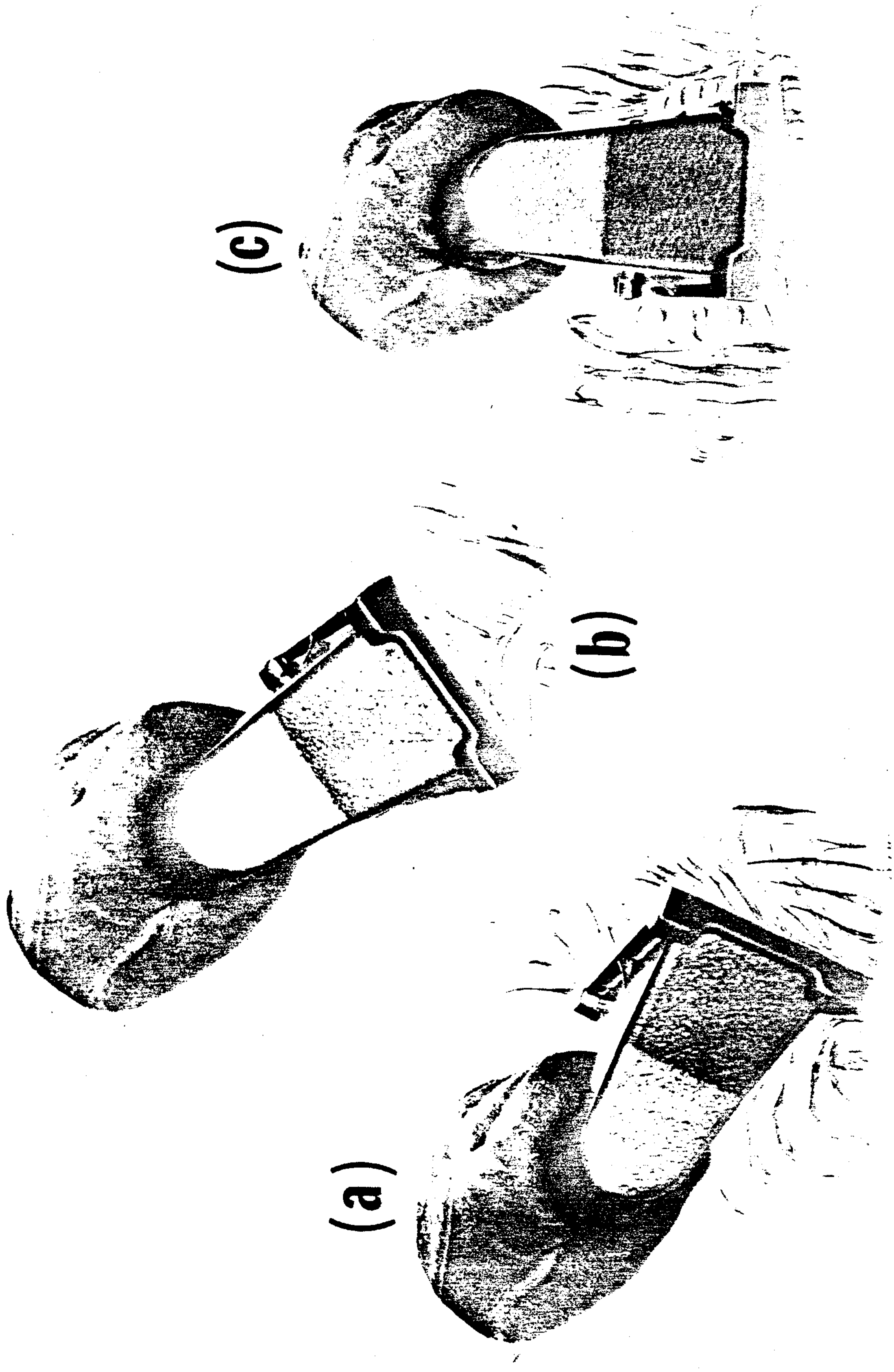

Figure 8-5. Positioning of probe on grassy surface.

Table 8-3. Converted Readings for Some Common Surfaces, Radiacmeter IM-170

Meter reading (cpm)	Contamination level ($\mu g\ ^{239}Pu/m^2$)			
	Concrete	Soil	Plywood	Smooth
20,000	100	118	83	50
40,000	200	235	167	100
60,000	300	353	250	150
80,000	400	471	325	200
100,000	500	588	417	250
200,000	1,000	1,176	833	500
300,000	1,500	1,765	1,250	750
400,000	2,000	2,353	1,667	1,000
600,000	3,000	3,529	2,500	1,500
800,000	4,000	4,706	3,333	2,000
1,000,000	5,000	5,882	4,167	2,500
1,200,000	6,000	7,059	5,000	3,000
1,400,000	7,000	8,235	5,833	3,500
2,000,000	10,000	11,765	8,334	5,000

8–5. Air Monitoring

a. Alpha particle emitters present a very serious hazard once they enter into the body. Since inhalation is the principal route of entry into the body, the amount of radioactive contamination in the air must be measured. The amount of alpha emitters deposited in the body depends largely on their concentration in the inhaled air, the particle size, and the length of time an individual is exposed. The maximum permissible airborne concentration for ^{239}Pu (insoluble plutonium oxide) has been established, for both restricted areas and unrestricted areas, by Title 10, Code of Federal Regulations, Part 20. These limits, given in microcuries per milliliter ($\mu Ci/ml$),[1] are as follows:

Restricted area: $4 \times 10^{-11}\ \mu Ci/ml$ (40 hour/week exposure).

Unrestricted area: $1 \times 10^{-12}\ \mu Ci/ml$ (continuous exposure).

The only way to determine the airborne concentration present at or near the accident site is to collect and analyze air samples.

b. In a nuclear accident that results in large-scale air contamination, the particulate matter will probably have been deposited on the ground or dispersed before air sampling can be initiated. The problem in most cases is one of determining the hazard due to resuspension of the contaminants that are already on the ground.

c. Air monitoring includes the collecting of particles suspended in the air (sampling), measuring the radioactivity of the collected sample (analysis), and calculating the amount of radioactive material per unit volume of air.

8–6. Air Sampling

Air sampling must be performed to determine the airborne contamination at a specific location and time and/or to determine the contamination in an area over a period of time. The samples are divided into two principal types, based on the length of time involved in the collection.

a. Spot Sample. A spot sample is usually taken for a period of less than 10 minutes and, when analyzed, indicates the airborne contamination at a precise location at a given time.

b. Continuous Sample. A continuous sample is taken over a measured period of time, usually ½ hour or more (or until 1,000 cubic feet of air have been sampled), and indicates the average conditions in the sampled area over the period of time during which the sample was taken. This type of air sample will represent the conditions under which individuals may have been exposed.

8–7. Air Sampling Equipment

a. There are a number of different methods for obtaining a continuous air sample. The physical state of the contaminant will determine the collecting procedure used to evaluate the quantity of radioactive contamination. For a particulate contaminant, methods such as filtration, impaction, impingement, and electrostatic precipitation may be used. Trays that have been coated with an adhesive may be used as collectors to make a qualitative check of airborne particles or to detect resuspension and spread of the contamination. However, for a gaseous contaminant, different methods are available. Certain gaseous contaminants are either absorbed

[1] For air, at standard temperature and pressure, 1 milliliter (ml) is equivalent to 1 cubic centimeter (cc). One curie equals 3.7×10^{10} nuclear transformations per second (abbreviated Ci). A microcurie is one-millionth of a curie (3.7×10^4 disintegrations per sec.) (abbreviated μCi).

into or adsorbed onto a collecting material which is then evaluated. Other radioactive gases, particularly tritium, can be detected and counted by passing a sample through a flow-through ionization chamber which will produce an instantaneous indication.

b. Filtration is the most practical air sampling method at a nuclear accident site. Devices that utilize filter papers are described below.

(1) The Staplex high-volume air sampler is an example of a vacuum-type apparatus used to draw large volumes of air through a high efficiency filter paper. The efficiency of any sampler is ultimately determined by the type of filter paper used. Collection and detection of an alpha emitter requires a tight weave and fine grade filter paper such as Staplex Model TFA-66 or Whatman 41. The flow rate of the sample will be determined by the apparatus and filter paper used. The Staplex high-volume air sampler (fig 6-4), Model TF1A-27, requires 110-volt, 60-Hz alternating current. Model TF1A-4 requires 24-volt direct current.

(2) There are a variety of other electrically operated air samplers that may be used; even an ordinary home vacuum cleaner can be used if the flow rate is calibrated.

8-8. Air Sampling Procedures

a. Location. Samplers will be located so that the extent and amount of airborne contamination can be determined both downwind and at th accident site. Placement of the air samplers is vital if the data are to be valid. Figure 8-6 shows how air samplers might be employed by the RADCON team at an accident site. An air sampler is placed at least 610 meters (2,000 feet) upwind from the accident site to obtain a background air sample. One 30-minute sample is adequate for determining background radioactivity. Another air sampler should be placed at the contamination control station (para 9-4*a*) and operated continuously during the operation since personnel in this area may resuspend contamination.

Note. The Alpha Team, being authorized only three air samplers, must use one sampler to perform both of the foregoing functions. After the background sample is obtained, the sampler is maintained at the contamination control station for continuous sampling.

An air sampler is placed about 25 meters downwind from the accident site to determine the hazard in the immediate area and is operated continuously. The last sampler is placed downwind from the accident site at a distance dependent on the wind velocity (table 8-4). This air sampler should be operated until it can be safely assumed that there is no danger of airborne contamination at that point. Consideration should be given to changing and evaluating sampler filter paper periodically.

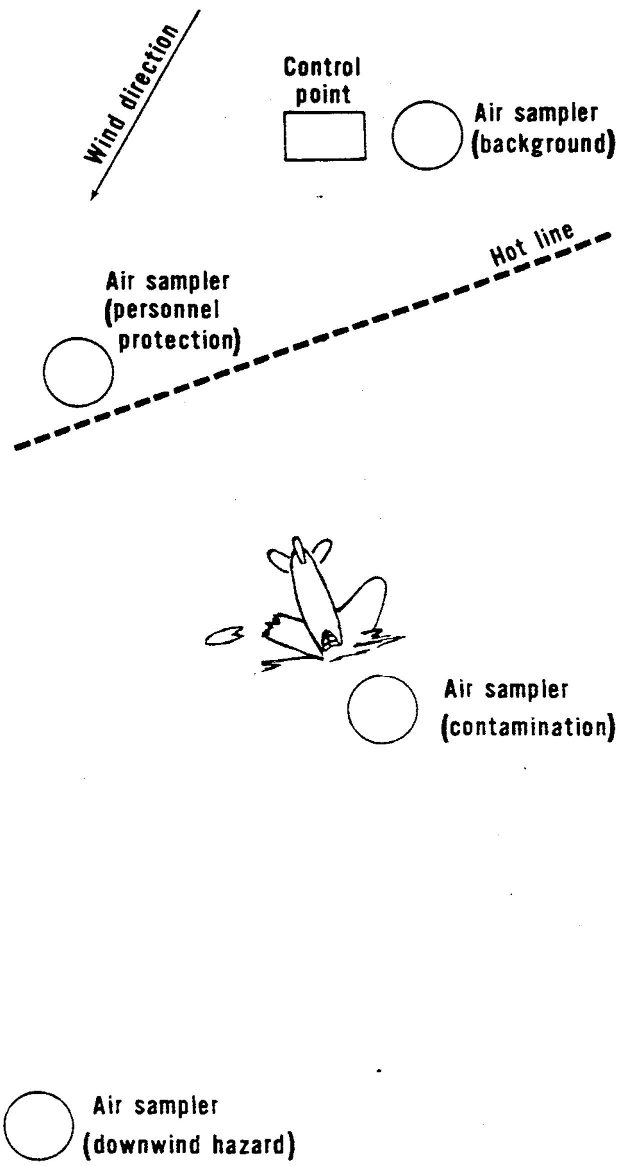

Figure 8-6. Air sampler employment.

Table 8-4. Air Sampler Placement

Wind velocity (mph)	Wind velocity (knots)	Downwind distance (meters)
6-10	4-9	1,050
11-15	10-13	1,550
16-20	14-17	2,050
Above 20	Above 17	2,550

b. Rate. Any sampling rate may be used as long as it is known along with the collecting efficiency of the sampling apparatus. The manufacturer's rated flow rate may be used; however, to assure accuracy, the sampler equipped with the type filter being used should be calibrated at the accident site. Samplers calibrated at sea level must be recalibrated at higher altitudes because of the lower air density.

c. Period. The length of sampling time will depend on the flow rate, amount of airborne dust that may cause filter clogging, and the volume required to detect maximum permissible concentrations. Samples of 100 to 1,000 cubic meters of air are necessary to obtain results within ±10 percent of true concentrations.

d. Recording Data. The following data should always be recorded for air samples:

(1) Location of sampler and height above ground.

(2) Average flow rate.

(3) Total sampling time.

(4) Type of sampler.

(5) Size and type of filter paper.

(6) Type of radioactive material, if known.

(7) Wind and weather conditions.

(8) Operations being performed in the area during the sampling period.

(9) Any other pertinent data.

8–9. Analysis of Air Sampling Data

a. A radioactive aerosol is evaluated by measuring the radioactivity of the sample collected with either a portable radiac device or a laboratory counting system. For an accurate determination, laboratory counting is required. If a heavy layer of dust is collected on the filter, absorption of the alpha radiation by the dust may preclude accurate counting of the sample. A shorter sampling time will result in a reduced dust load on the filter paper and allow a direct count of the sample. It should be emphasized that this method will only indicate whether contamination is present. It is not an accurate quantitative measurement using the AN/PDR–60.

b. After the air sample has been counted, corrections must be made for self-absorption by the filter paper. The dust particles collected on the filter paper will penetrate a finite distance into the paper, and part of the activity is absorbed by the paper and not measured by the counter. This is particularly true for alpha emitters. The correction factor for self-absorption may be obtained by counting the paper, burning it, plating out the remaining radioactive ash on a metal disk, and recounting it. In some instances, this factor may be obtainable from the manufacturer or from other sources. Using Whatman No. 41 filter paper, about 70 percent of the alpha emitter is actually counted. With millipore filters, electrostatic precipitators, and cascade impactors, the count is nearly 100 percent, i.e., little or no self-absorption occurs. Counting of samples should be done with laboratory counting equipment on the operations described in this paragraph and in *c* below. The AN/PDR–60 is not sufficient for these operations.

c. Another correction factor to be considered is the background, which is due to radioactive materials normally present in the atmosphere in a given area. The background count for air samples may range from 10^{-9} μCi/cc to 10^{-11} μCi/cc. This background count is due primarily to the spontaneous decay of radium and thorium in the earth's crust. The concentration in the air will vary greatly with location and time; therefore, no fixed correction factor can be used. There are three methods that may be used to correct for this background count.

(1) *Multiple samples.* Simultaneous samples are taken outside and inside the contaminated area. The outside sample is used for background correction and indicates the extent to which decay products interfere with the determination of long half-life alpha emitters. For details see TM 3–260.

(2) *Decay compensation.* The immediate decay products of radon (^{222}Rn) may be considered completely decayed 4 hours after completion of sampling. The critical thoron (^{220}Rn) decay product, thorium B (^{212}Pb) with a half-life of 10.6 hours, will not decay to negligible proportions before about 72 hours. However, the decay of thoron may be estimated by taking two counts: one, 4 hours after sampling; and another, at least 24 hours after sampling. The activity due to long half-life alpha emitters may be computed from the two counts by use of the following equation:

$$C_{LL} = \frac{C_2 - C_1 e^{-\lambda \Delta t}}{1 - e^{-\lambda \Delta t}},$$

where, C_{LL} = counts due to long-lived isotopes (cpm),

C_1 = counts resulting from first count (less background of counter) (cpm),

C_2 = counts resulting from second count (less background of counter) (cpm),

λ = decay factor hrs^{-1}) (for thoron, λ = 0.0655),

Δt = time between counts (hrs), and

e = base of natural logarithms (2.7183).
If the measurements are made at exactly 4 and 24 hours, the equation becomes

$$C_{LL} = \frac{C_2 - 0.270\ C_1}{0.730}$$

(3) *Shielded samples.* A rough indication as to the activity of long half-life alpha emitters may be obtained by counting the contamination on the filter paper and then placing the filter paper in a glassine envelope, which the alpha radiation will not penetrate, and taking a second count. The radon and thoron activity (from daughter beta and gamma rays) will be reduced to about 30 percent by the glassine envelope; thus,

(*a*) If the second reading is about 30 percent of the first, the majority of activity is due to radon and thoron.

(*b*) If the second reading is less than 30 percent of the first, long half-life alpha emitters may be present in significant concentration.

(*c*) If the second reading is nearly zero, the majority of the activity is due to long half-life alpha emitters.

8-10. Calculation of Air Concentrations of Contamination

a. Calculations of air concentrations of alpha-contaminated aerosols are normally reported in μCi/ml. These calculations should be made using laboratory counting equipment. To evaluate the activity, the following data are necessary:

(1) Total activity (cpm).

(2) Background activity (cpm).

(3) Total volume of air passed through the filter (m^3).

(4) Fraction of filter area counted.

(5) Efficiency of filter.

(6) Fraction of activity not self-absorbed.

(7) Counting efficiency of the instrument used.

(8) Conversion factor for cpm/m^3 to μCi/ml (as used in this equation is 4.4×10^{12}).

b. To convert the activity to μCi/ml, apply the data from *a* above as follows:

$$\text{Activity}\ (\mu\text{Ci/ml}) = \frac{(1)—(2)}{(3)(4)(5)(6)(7)(8)}.$$

If the concentration of long-lived (C_{LL}) alpha emitters is determined by the method in paragraph 8-9*c*(2), the value of C_{LL} is used in place of (1)—(2) in the numerator above. For details, see TM 3-260.

c. This equation, unfortunately, imposes a delay in obtaining data on airborne concentrations of radioactive material. In the event of an emergency, it is necessary to determine the airborne contamination with as little delay as possible. Using a standard, high-volume air sampler (Staplex), the data can be evaluated for field use with the IM-170/PD or IM-154/PD radiacmeter for alpha contamination by the following equation:

$$\text{CONC} = \frac{\text{cpm} \times F}{\text{cfm} \times T},$$

where, cpm = instrument reading in counts per minute,
cfm = flow rate in cubic feet per minute,
T = sample time in minutes,
F = correction factor (table 8-5), and
CONC = concentration either in counts per minute per cubic meter (cpm/m^3) or microcuries per milliliter (μCi/ml), depending on the correction factor (F) used.

The background radioactivity should be subtracted from calculated airborne contamination before applying the data to protection standards (table 3-1).

*Table 8-5. Correction Factors for Field Air Sampling.**

Filter paper size	F for cpm/m^3	F for μCi/ml
8- by 10-inch	2,000	5×10^{-10}
4-inch diameter	400	1×10^{-10}
1-inch millipore	300	1×10^{-10}

*The factors given in this table are for Whatman 41 filter paper, using either the IM-170/PD or the IM-154/PD radiacmeter. For conditions other than these, the equation in paragraph 8-10*b* must be used. This table will provide an answer of the correct order of magnitude only, not a precise value.

8-11. Water Sampling

Water sampling involves collecting a representative volume of water (100 to 1,000 ml) and sending it to a laboratory for measurement of the radioactivity of the collected sample and calculation of the amount of radioactive material per unit volume of water. The primary precaution to observe in collecting and handling water samples is to prevent additional contamination of the samples.

a. Equipment. The only item required for water sampling is a container in which to collect and ship the sample. This container can be made of glass, plastic, or metal and should be sealed to prevent evaporation.

b. Collection Procedures. If the sample is taken from surface water, it should be taken away from the edge of a pond or stream to avoid debris and to obtain a representative sample. If the sample is to be taken from a faucet, water should be allowed to run a short time before the sample is taken.

8-12. Analysis of Water Samples

There is no portable radiac instrument capable of detecting alpha contamination in water. This must be done by appropriate laboratory analysis. A reading above background on the IM-141/PD radiacmeter [AN/PDR-27( )] indicates a concentration of an unidentified beta-gamma emitter in excess of 10^{-3} μCi/ml. The maximum permissible concentration of an unidentified radionuclide in water is 10^{-8} μCi/ml. The IM-141/PD radiacmeter cannot determine activities in water lower than 10^{-3} μCi/ml. Thus, unless the water is evaporated from the sample before measurements are made, significant radioactive contamination may not be detected. Since such evaporation in the field would be most difficult, water samples should also be checked for beta-gamma contamination by appropriate laboratory analysis. However, as a general procedure, water samples should be checked with the IM-141/PD radiacmeter.

8-13. Performance of Air and Water Sampling

Air sampling and water sampling are performed by the RADCON team. Air sampling, using the procedures outlined in paragraph 8-10*c*, can also be performed by the Alpha team, if it has the necessary equipment.

CHAPTER 9

CONTAMINATION CONTROL

9–1. General

a. Rigidly established operating procedures must be followed to prevent the spread of contamination. This is accomplished in three steps:

(1) Initial monitoring upon arrival to determine the extent of contamination in the area.

(2) Taking protective measures to preclude the spread of contamination.

(3) Establishing a contamination control station (CCS) to reduce contamination during operations.

b. It must be borne in mind that the instrumentation available to the Alpha team is "field instrumentation" for emergency use pending the arrival of the RADCON team. These instruments cannot accurately measure the very low permissible remaining contamination levels established for personnel, materiel, and terrain. Table 11–3, Acceptable Emergency Remaining Contamination Levels (Alpha Team Instrumentation), has been constructed as a practical guide to interpretation of "field instrument" readings following the application of decontamination procedures. All personnel, materiel, and terrain decontaminated under the auspices of the Alpha team must be reevaluated upon arrival of the RADCON team.

9–2. Initial Monitoring

a. Initial monitoring is performed immediately upon arrival at the accident scene by the Alpha team. Personnel at the accident site and the ground in the area must be thoroughly monitored for alpha and beta-gamma radiation. Area monitoring within the area of the accident site should be done only after the EOD team has completed render-safe procedures. Contaminated objects, personnel, and areas must be segregated before detailed operations are initiated; otherwise, team equipment and members may become contaminated. Civilian personnel who may have become contaminated may present special problems. Military personnel cannot forcibly detain, monitor, or segregate civilians. Therefore, the hazards should be explained to them in order to elicit their cooperation. Care must be taken not to alarm the civilian population unnecessarily. Civilian authorities present at the accident scene usually constitute the most effective means of dealing with civilians. It is essential to determine as quickly as possible the area contaminated. A method by which this can be accomplished rapidly, by the monitors of the Alpha team, is discussed in *b* below. This method should be modified to fit the accident site.

b. An alpha and beta-gamma rough point survey to determine the approximate size of the contaminated area can be conducted rapidly by two monitoring teams. At this time, the initial exclusion area of 610 meters radius (2,000 feet) against high explosive hazard has been established as shown in figure 9–1. The area around the accident site is monitored at four to eight points. As these points are approached, the beta-gamma readings are noted; the presence of alpha contamination can be determined by using the PG–1 probe to detect the weak gamma emitted by plutonium-239. When a reading of 10 mrad/hr beta-gamma or an indication of alpha (twice the background count) is obtained, the point is marked. If significant contamination is detected, caution should be exercised in taking the downwind readings because of possible airborne contamination. The area inside the points marked is used as the probable contamination area until time permits a more detailed survey to be conducted (fig 9–2).

c. Once an initial exclusion area has been established, actions should be taken to remove extraneous civilian and military personnel from the accident scene to a clean area. Before leaving the exclusion area, all personnel and equipment should be thoroughly monitored. Clean areas must be located upwind of the accident site. Sites within the clean areas must be selected for the location of the control point, hot line, and other control facilities. After the control procedures have been initiated, a complete survey of the area must be conducted to determine the exact size of the 1,000 $\mu g\ ^{239}Pu/m^2$ alpha and/or 10 mrad/hr beta-gamma exclusion area.

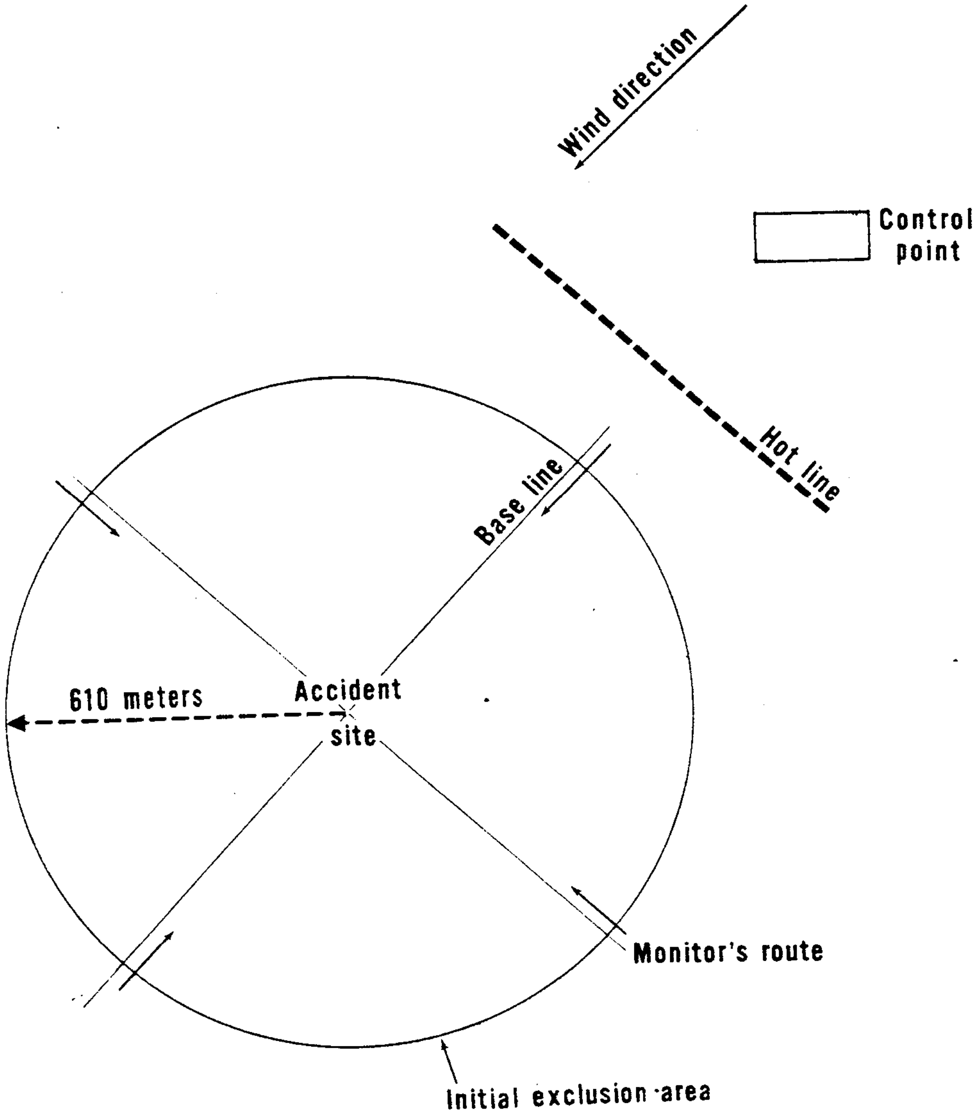

Figure 9-1. Initial exclusion area.

Detailed survey procedures are discussed in paragraphs 10-1 through 10-4.

9-3. Protective Measures

a. Since alpha contamination is an internal hazard, adequate precautions must be taken to prevent entry into the body. Alpha contamination can be inhaled, ingested, or absorbed through cuts and breaks in the skin. Maximum protection must be provided to prevent contamination of the individual and the air he breathes. Effective protective measures are an important aspect of contamination control and will greatly reduce the hazard to personnel and the subsequent decontamination efforts for equipment and personnel.

b. It is quite difficult to protect some equipment against contamination because of size and usage. However, through proper selection, protection, and control, this problem can be reduced. If possible, equipment should never be placed directly on the ground because of possible contamination. Some expendable material (such as heavy paper) should be placed beneath all items, including equipment in plastic bags. Only the minimum amount of equipment should be used. If possible, the same equipment should be used in repeated operations in the contaminated area, rather than bringing in additional clean equipment for each operation. For example, transportation vehicles should be divided into two groups, with one group for exclusive use in the contaminated area. All selected equipment must be kept as clean as possible to reduce spread of contamination and decontamination problems. All equipment used in the contaminated area should be decontaminated at

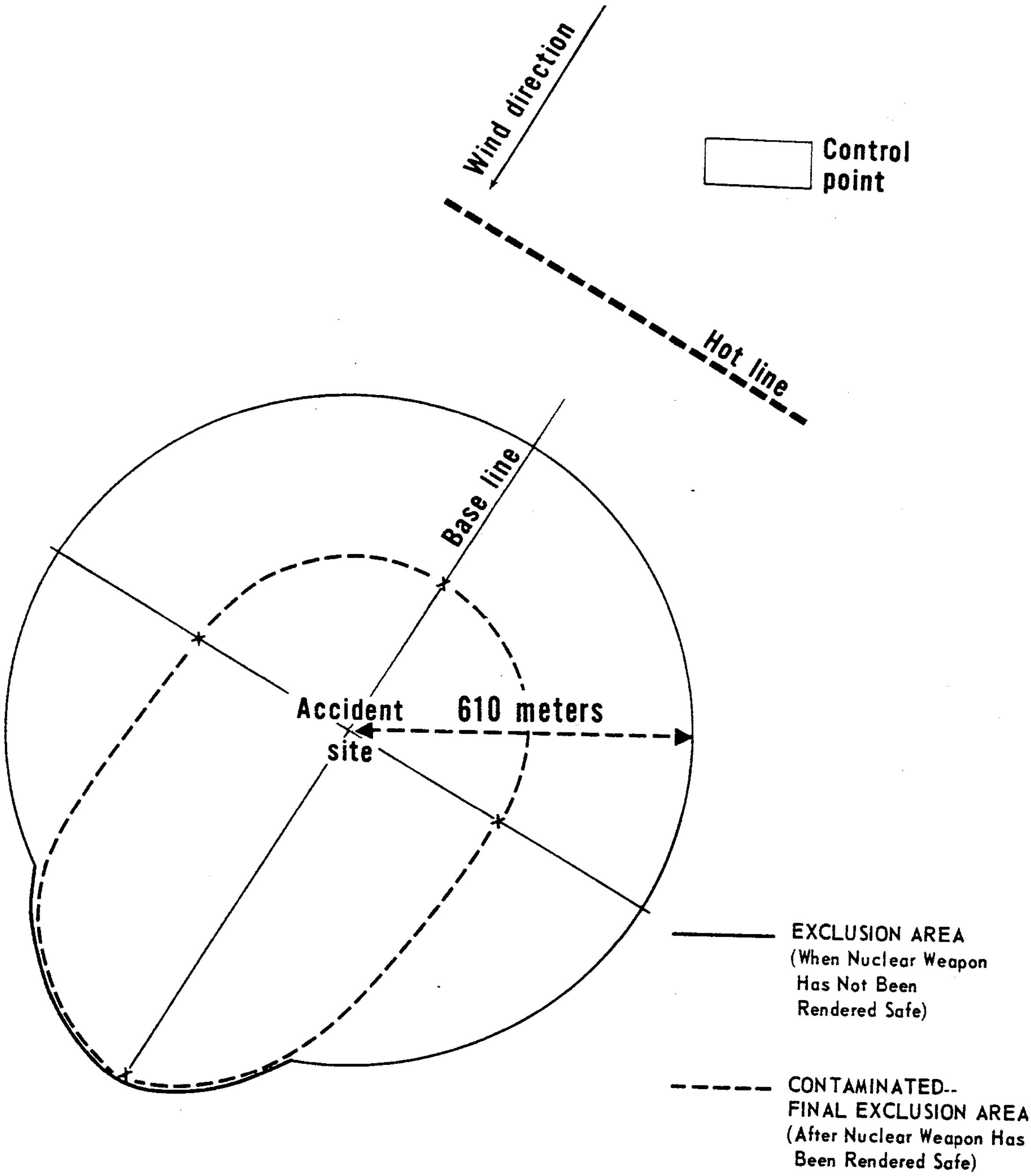

Figure 9–2. Final exclusion area.

the end of each operation. However, this equipment should remain on the hot side of the hot line until all cleanup is completed. This will reduce the number of contaminated vehicles and the possibility of spreading the contamination into the clean areas.

c. Certain equipment, such as radiacmeters, can be enclosed in plastic bags and the cables covered with masking tape or plastic tubing of 4 mil thickness sealed at the ends to reduce the possibility of contamination. However, alpha instrument probes must be left uncovered (fig 9–3).

d. Personnel entering a contaminated area must be fully dressed in protective clothing. This clothing will not reduce exposure to beta-gamma radiation but will reduce the body contamination, help prevent the spread of contamination, and ease subsequent decontamination work. Protective clothing should consist of—

(1) Coveralls, two sets. (One set may be of disposable material.)

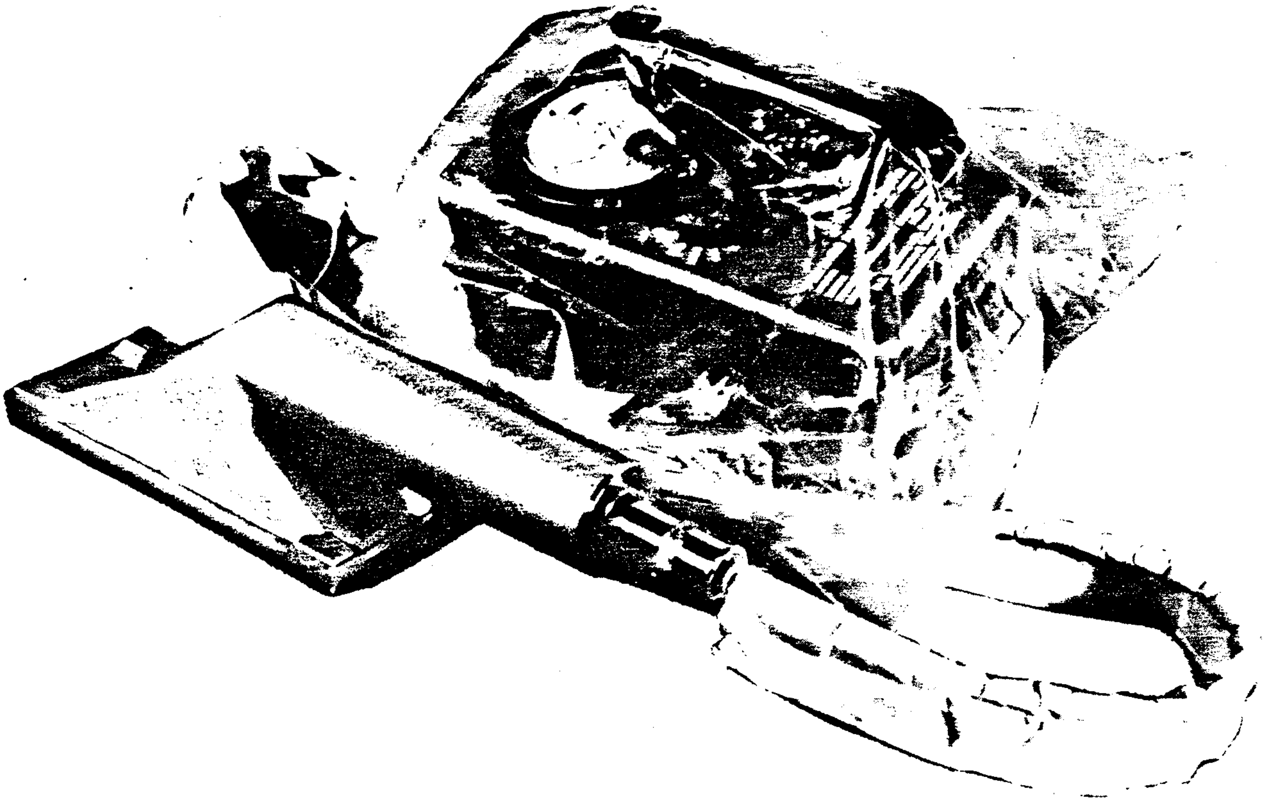

Figure 9-3. Alpha survey instrument enclosed in protective plastic (probe left uncovered).

(2) Shoe covers.

(3) Cotton gloves.

(4) Hood or hair cap (i.e., surgeon's cap).

(5) Respirator. (The high-filtration respirator will be worn when required by table 3-1 or paragraph 3-4.)

All openings in the clothing must be taped closed (fig 6-2, 6-3, 6-4) so that there will be no entry of contamination into the body. This protective clothing will be systematically removed during passage through the contamination control station to minimize the spread of contamination [fig 9-4 and para 9-4*d*(5) (*d*)-(*h*)]. The protective clothing is then packaged and processed as contaminated clothing.

e. In instances where protective clothing as outlined in *d* above is not available, fatigues may be worn. As in the case of protective clothing, all openings must be taped closed. The use of fatigues presents an added problem in that clothing must be provided for personnel exiting the area, as they will not be permitted to leave in contaminated fatigues.

9-4. Contamination Control Station (CCS)

a. The contamination control station (CCS) is a facility to prevent further spread of contamination. The CCS is established by the OSC/NAICO during the initial entry and is situated upwind from the accident site. It must be in an area that is free of radioactive contamination. All personnel working in the CCS area must be fully dressed in work clothes plus coveralls or two pairs of coveralls, shoe covers, hood or hair cover, and surgical gloves, with a protective mask or respirator and tape to cover openings. All personnel and equipment entering and leaving the accident scene are channeled through the CCS. No one must be allowed to enter the clean area until he has been monitored and decontaminated. Further, no items or equipment must be allowed to pass into the clean area until they have been monitored and decontaminated and packaged.

b. The CCS consists of three elements (fig 9-4):

(1) *Hot line.* The hot line is a line separating

the contaminated area from the contamination reduction area.

(2) *Contamination reduction area.* This area contains several stations and various items of equipment and supplies used to eliminate, or reduce to an acceptable level, contamination picked up by personnel operating in the contaminated area.

(3) *Contamination control line.* This line is a control line separating the contamination reduction area from the clean area.

c. The CCS equipment listed below can best be employed as illustrated in figures 9-4 and 9-5.

(1) Protective clothing stand.

(2) Plastic bags.

(3) Masking tape (2- and 3-inch widths).

(4) Radiation signs and labels.

(5) Communication equipment: AN/PRC-77 (or similar type) radio and/or field phone.

(6) Decontamination supplies: water, detergent, alcohol, cotton, talcum powder, paper towels, surgical rubber gloves.

(7) Radiation detection equipment: AN/PDR-60 and AN/PDR-27( ).

(8) Check source for alpha instruments.

(9) Miscellaneous: spare personnel protective equipment, heavy paper, drinking cups and water, field table.

d. Recommended operational procedures for the CCS are outlined below.

(1) Designation of a hot line by engineer tape, masking tape, or a line scratched on the ground. A space at least 6 meters (20 feet) wide is necessary.

(2) Deployment of CCS equipment as illustrated in figure 9-4.

(3) Use of an established sequence of actions (SOP) by team members preparing to enter the accident area.

(*a*) Dress out in coveralls and shoe covers; tape openings.

(*b*) Adjust protective mask for proper fit; remove mask.

(*c*) Check radiacmeters and other equipment for proper operation.

(*d*) Put on cotton gloves and tape wrist openings.

(*e*) Don protective mask and hair cap or hood.

(*f*) Undergo inspection by CCS personnel for proper taping of clothing and functioning of equipment before crossing the contamination control line.

(4) Placement of all equipment and data on a large piece of paper adjacent to the hot line by personnel approaching from the accident area.

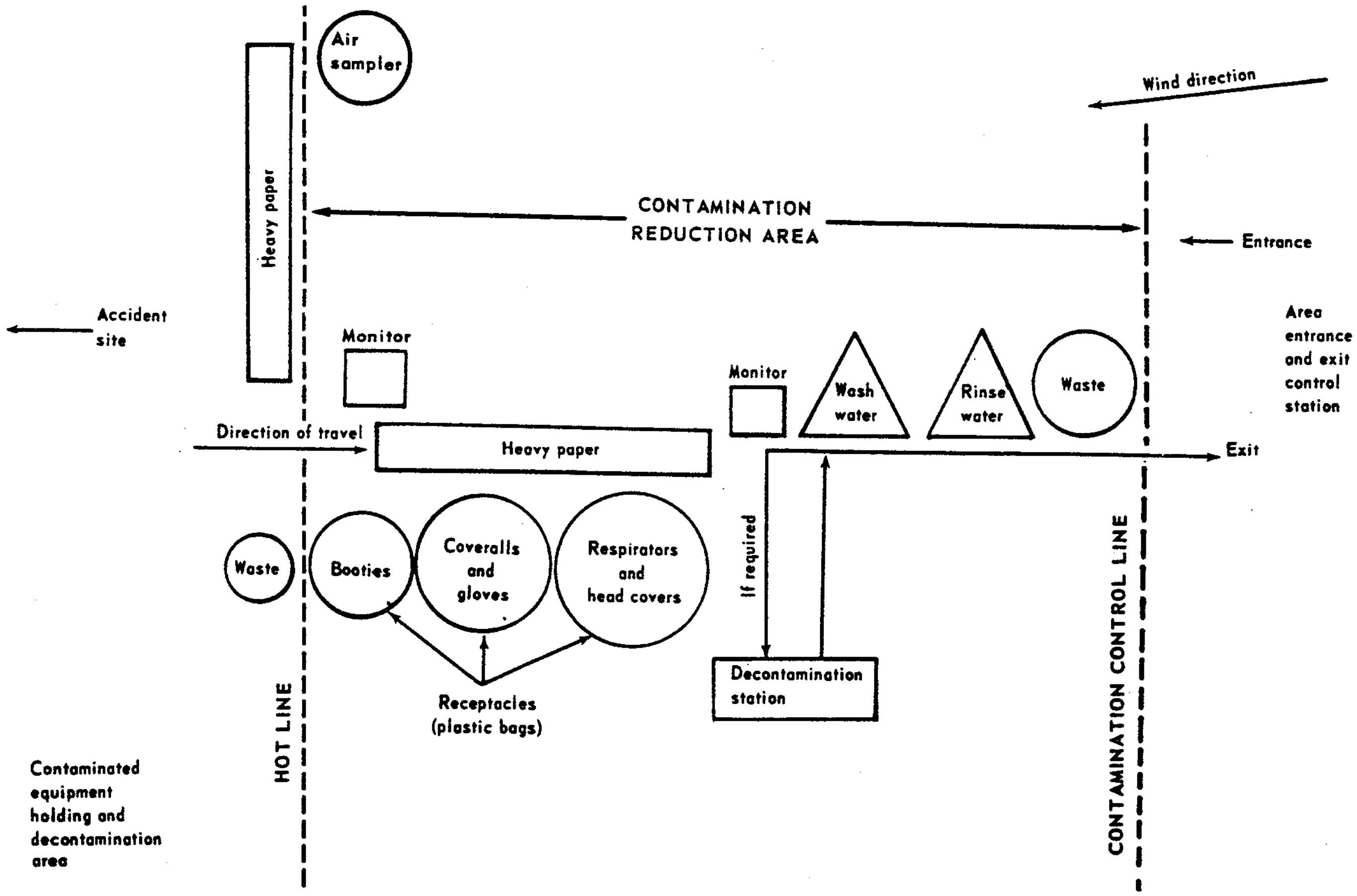

Figure 9-4. Contamination control station (CCS) setup.

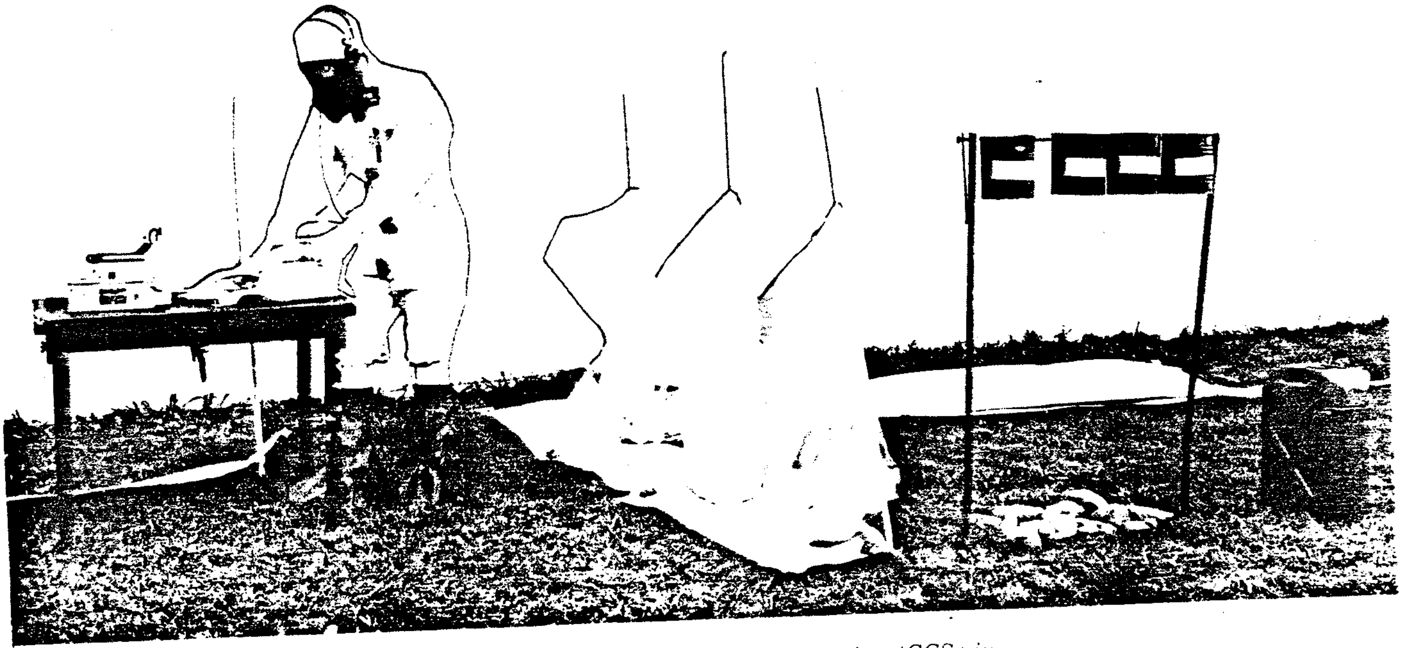

Figure 9–5. Contamination control station (CCS) in operation.

(5) Use of an established sequence of actions by team members returning from the accident area.

(*a*) Place all portable equipment and survey data on a large piece of heavy paper or similar material adjacent to the hot line.

(*b*) Prepare to move single file through the contamination reduction area in an orderly manner.

(*c*) Upon reaching the hot line, remove all tape from outer clothing and deposit it in a waste receptacle (plastic bag).

(*d*) Remove one shoe cover, have foot monitored for alpha and beta-gamma contamination by CCS personnel, step across the hot line with that foot, and place the shoe cover in the plastic bag. The probe of the instrument will be placed in contact with the surface being monitored. Remove the other shoe cover, have foot monitored. step completely across the hot line with that foot, and place the shoe cover in the plastic bag. (No one is allowed to proceed any farther if shoes are contaminated. Take action discussed in (*g*) below.)

(*e*) Remove the outer coveralls, hood, and gloves and place in the appropriate containers. Care must be taken to avoid contaminating the inner coveralls with the gloves or contaminating the bare hands with the outer coveralls.

(*f*) Undergo detailed monitoring of the entire body for both alpha and beta-gamma contamination. Especially check the neck, hands, and feet.

(*g*) Remove the protective mask upon completion of monitoring. Nose swipes shall be taken. A urine sample will be collected if internal contamination is suspected. Personnel found to be contaminated should be sent to a decontamination station, if one is available. These personnel should be remonitored before exiting the contamination reduction area.

(*h*) As the final step in the sequence, thoroughly wash the face, neck, and hands; follow this as soon as possible with a complete body shower.

(6) Periodic check of the CCS area for contamination during operations. Upon the conclusion of operations, the contaminated clothing bags are sealed, monitored, and labeled. The CCS area is checked for contamination before abandonment. Final release of the area will be authorized by the OSC on recommendation of the RADCON team leader and the Medical team leader.

e. The CCS should be as complex as the situation demands. In large-scale operations over extended time periods, this may include quartermaster bath units and/or CBR decontamination teams. The CCS shown in figure 9–5 is a simple field setup using normal unit equipment.

CHAPTER 10

SURVEY TECHNIQUES

10-1. General

Upon notification of a nuclear accident, the Alpha team will proceed to the accident site as quickly as possible. If an EOD team arrives at the site first, its knowledge of the type of weapon involved and its preliminary radiological estimate of the situation will be available to the Alpha team. Site control procedures are discussed in section IV. An immediate survey will be conducted to determine the presence of significant levels of hazardous contamination (para 9-2*b*). Entry into the actual accident site should be made only after the EOD team has completed render-safe operations.

10-2. Alpha Team Survey

a. Upon arrival at an accident site, the Alpha team leader should coordinate with military and civilian personnel at the scene of the accident. An area at least 610 meters (2,000 feet) in radius, known as the initial exclusion area (fig 9-1), must be cleared of personnel, and control of this exclusion area established. Personnel who have been in this area should be monitored for possible contamination. The team leader should establish his control point outside the initial exclusion area at least 610 meters upwind of the accident site. The initial exclusion area is the minimum safe explosive distance; however, three additional factors must be considered. First, fragments flying from a high-order detonation may extend farther than 610 meters. Secondly, preliminary investigation may reveal that radioactive contamination hazards extend beyond a 610-meter radius. The exclusion area must be increased to compensate for any hazard that extends outside the original 610-meter radius. The final exclusion area (fig 9-2) should not be decreased until the area is released by the proper authority. The monitors will be provided with equipment necessary to monitor for beta-gamma and alpha radiation and to mark the contaminated area. Figure 10-1 shows an example of an approved type of radiological hazard marker which should be used in connection with nuclear accidents within CONUS. Thirdly, an effort should be made to minimize the electromagnetic environment at the accident site until EOD personnel have established that no hazard will be caused by electromagnetic radiation. Devices that require substantial radiation of electrical power to function, such as radio transmitters, radar sets, and the like, will not be operated within the TRANSMITTER EXCLUSION AREA shown in figure 10-2. This restriction does not apply to electric motors, generators, power-driver equipment, wired telephones, vehicle ignitions, and the like, provided they do not come in physical contact with the weapon. Radiating equipment may be used in the TRANSMITTER RESTRICTION AREA (fig 10-2) provided the weapon is not a missile that has been subjected to a launch environment and the equipment does not radiate a sum total output in excess of 100 watts. If the weapon is a missile which has been subjected to a launch environment, transmitters will not be used within a radius of 3.2 kilometers until such time as the EOD team has performed render-safe procedures. Upon completion of render-safe procedures, transmitters may be used within the TRANSMITTER RESTRICTION AREA.

b. After the exclusion area and the control point have been established, the Alpha team should make a rough point survey of the exclusion area. This survey is designed to give the Alpha team leader an immediate indication of the location and extent of the radiological contamination on the ground. The rough point survey should be initiated as soon as practical after arrival at the accident site.

(1) A rough outline of the contaminated area is approximated by monitoring along four radial lines with the PG-1 probe. The radial lines can be established along the four primary directions or by any other means that can be quickly set up and utilized at the accident site. One suggested method is for the Alpha team leader to shoot a base line downwind from his control point through the center of the accident site with a compass. The base line can be identified by stakes at either end outside the exclusion area. The second radial line is established

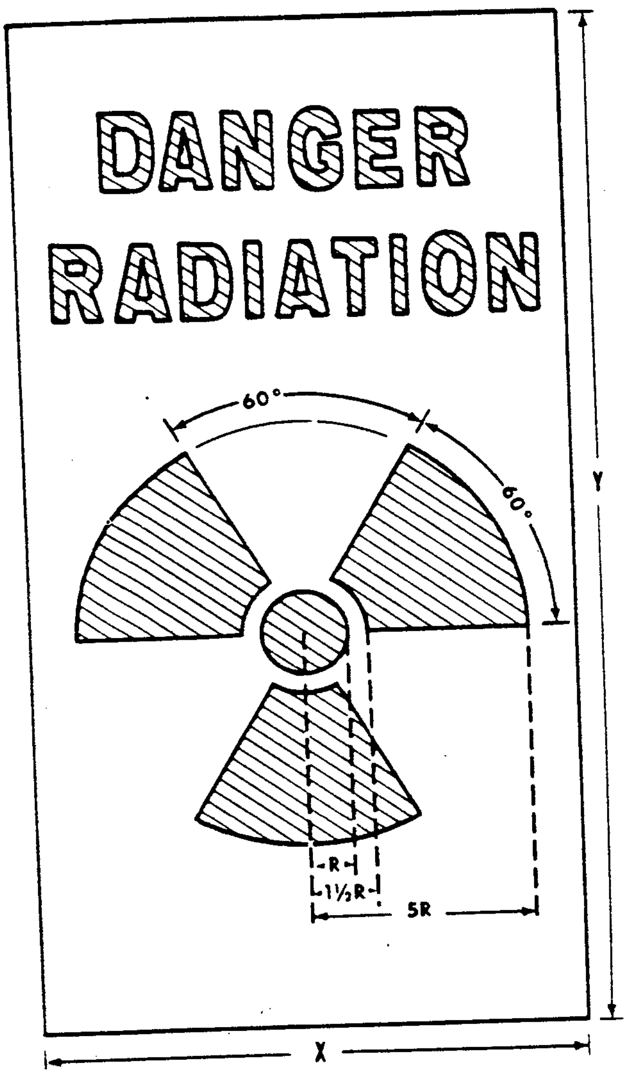

Figure 10-1. Radiological hazard marker (front and back).

at a 90-degree angle from the base line through the accident site (fig 9-1). Monitors enter and monitor inward along the radial lines until they get an indication of contamination. They mark this point on the ground with engineer tape.

(2) If contamination is found, the Alpha team leader will notify the OSC/NAICO, and the team monitors will use the isodose rate or isocon line method (para 10-3*b*), shown in figure 10-4, to perform a survey to delineate the contaminated area. The monitors will use the alpha instruments for determining the 1,000 μg $^{239}Pu/m^2$ contamination line, and the AN/PDR-27( ) for determining the 10 mrad/hr beta-gamma contamination line. If readings of 10 mrad/hr for beta-gamma or 1,000 μg $^{239}Pu/m^2$ are detected, the monitors will mark and record the locations. The monitors will then proceed in a clockwise manner, using the isodose rate method, and mark the 10 mrad/hr line for beta-gamma or the 1,000 μg $^{239}Pu/m^2$ line for alpha with engineer tape. The contaminated area will be defined by the 1,000 μg $^{239}Pu/m^2$ perimeter unless the 10 mrad/hr beta-gamma contour line extends out farther from the accident site.

(3) *If alpha or significant beta-gamma contamination is encountered, a RADCON team will be requested by the OSC/NAICO.* Upon arrival of the RADCON team, the Alpha team may assist the RADCON team as directed by the OSC/NAICO. Personnel, animals, and equipment being moved from the area will be monitored and, when necessary, decontaminated. After the contaminated area is marked, the team leader will report to the OSC/NAICO for further instructions.

10-3. RADCON Team Survey

The RADCON team will perform a detailed survey of the area around the accident site to include monitoring for hot spots of contamination outside the exclusion perimeter. Three methods for performing this survey are described below. The method most commonly used is the "in-and-out" method. The situation may require use of one of the other methods or an improvised method. There must be some means by which the monitors can locate themselves on the ground, regardless of the method used. This can be accomplished with a rough sketch using readily identifiable terrain features or by use of a compass. The system used will be designed for the specific situation encountered at the accident site. The control system used will be determined by the RADCON team leader. Reporting procedures will be outlined prior to the start of the monitoring effort.

a. "In-and-Out" Method (fig 10-3). Divide the area to be surveyed into four sectors and assign a monitoring team to each sector. Have the monitors proceed into the accident area and survey until the predetermined turnback reading in cpm or mrad/hr is encountered. Suggested turnback readings correspond to 3,500 μg $^{239}Pu/m^2$ for alpha and 10 mrad/hr for beta-gamma contamination. Then, have the monitors proceed out of the area at a different angle until the 1,000 μg $^{239}Pu/m^2$ level is encountered. The monitors must record and report the meter

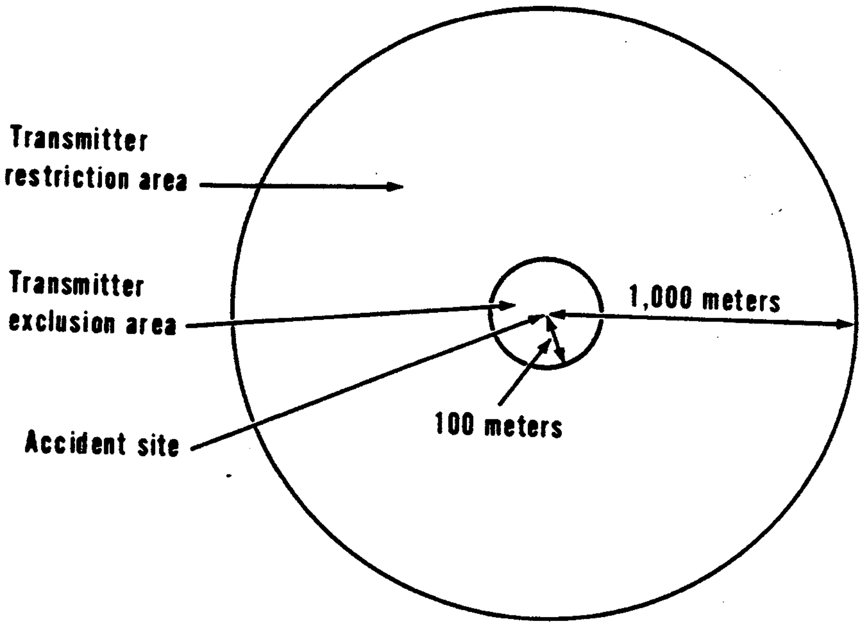

Figure 10-2. Transmitter exclusion and restriction areas.

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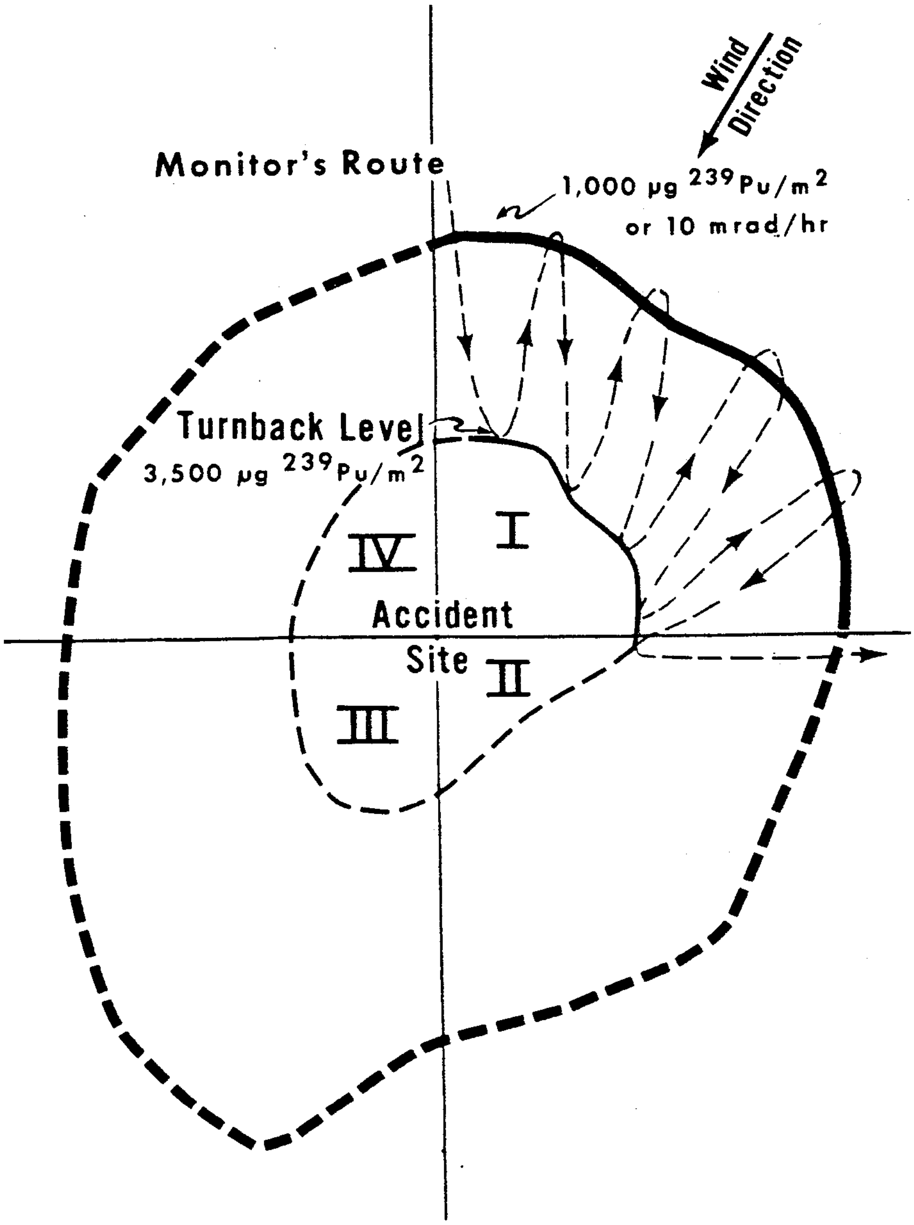


Figure 10–3. "In-and-out" method.

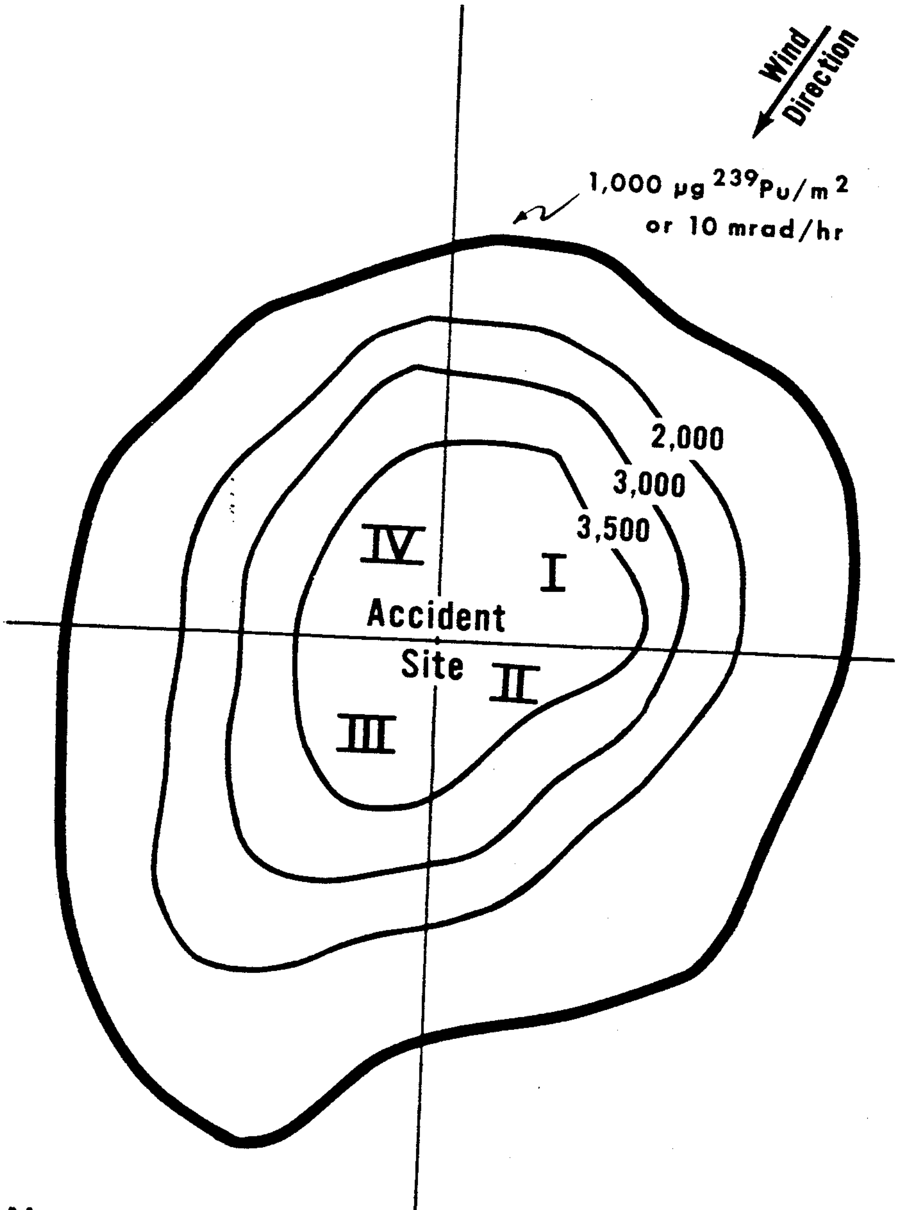
reading, the time, and location at which the readings are taken. If alpha contamination is present, the type of surface will determine what meter reading, in cpm, is used by the monitoring team (see table 8–2 for appropriate correction factors).

b. Isodose Rate or Isocon Line Method (fig 10–4). Divide the area into four sectors and have teams monitor for a given isodose rate or isocon line (a plotted contour line drawn at a uniform level of radioactive contamination) and define that line in their sectors. They may monitor for the 2,000, 3,000, and 3,500 μg $^{239}Pu/m^2$ alpha and 10 mrad/hr beta-gamma lines if so directed. Have the monitors report the time and location for all specified readings taken.

c. Grid Method (fig 10–5). Mark off the area in grids and divide into four sectors. Have the monitors record the reading and time at each grid line intersection in their sector.

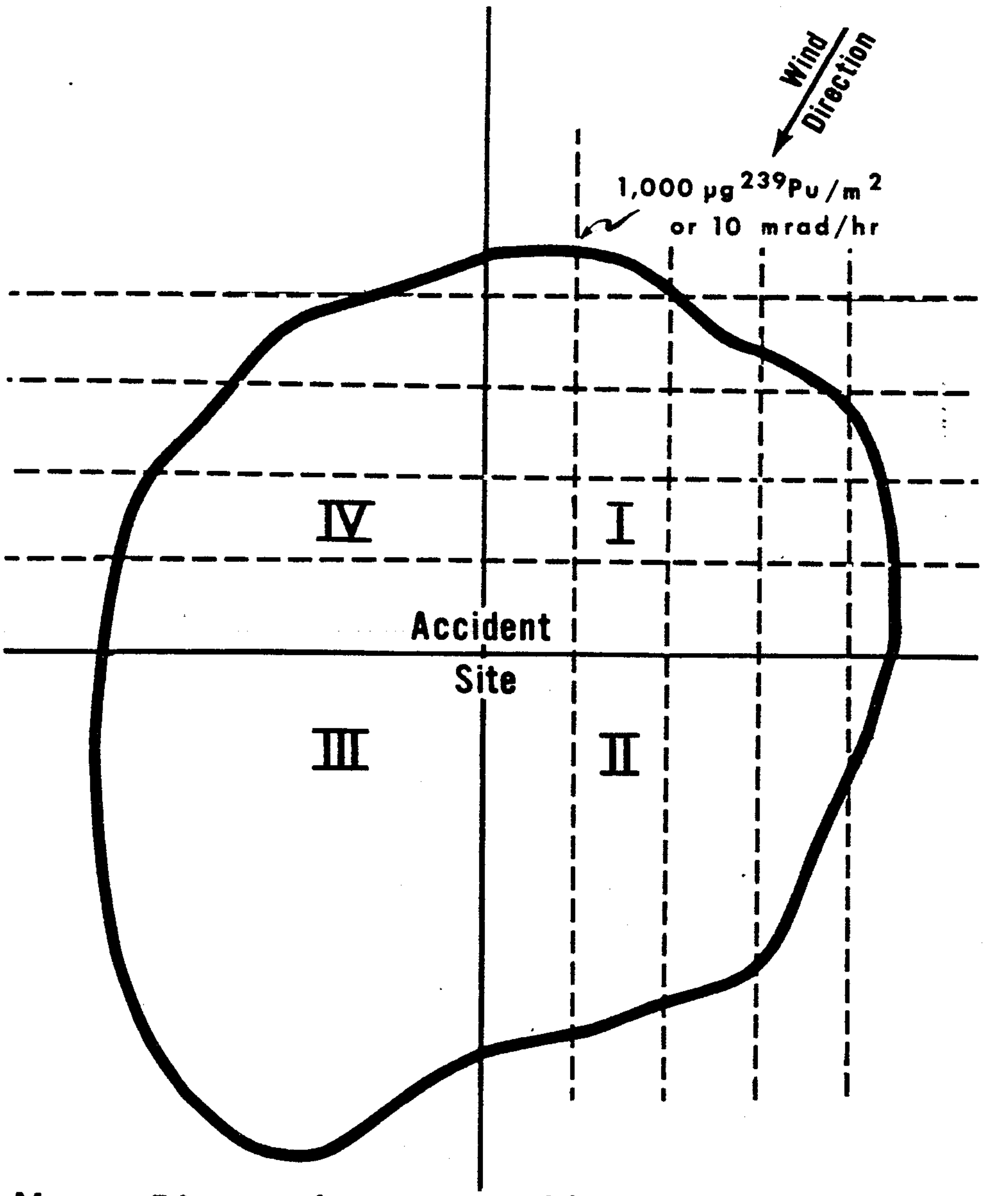
10–4. Personnel Dosimetry

a. General. Procedures will be established so that the total dose received by any individual during recovery operations will not exceed that specified by the OSC/NAICO at the accident site. AR 40–14 establishes the acceptable dose from all sources of nuclear radiation at 1.25



Note: Levels are preselected.

Figure 10-4. Isodose rate or isocon line method.



Note: Distance between grid lines depends upon local factors.

Figure 10-5. Grid method.

rem* per calendar quarter; 5 rem per calendar year. The maximum acceptable accumulated total dose from all sources of nuclear radiation is calculated using the formual: 5(n − 18), where n equals the age of the individual in years. These guidelines apply to all personnel, 19 years of age or older. No individual under 18 years of age may be intentionally exposed to ionizing radiation. Individuals between 18 and 19 years of age may be exposed to 1.25 rem per calendar quarter; however, their calendar year total dose may not exceed 3 rem. No pregnant female may be intentionally exposed to ionizing radiation. Larger doses are permitted for emergency operations, and are described below. For further details, see Title 10, Code of Federal Regulations, Parts 19 and 20, and AR 40–14.

b. Emergency Exposures. Specific dose criteria are set forth for two emergency categories by AR 40–14.

(1) *Saving human lives.* The OSC/NAICO may authorize emergency exposure of any individual, 19 years of age or older, to the following levels in order to save human lives:

(*a*) An accumulated whole body dose equivalent not to exceed 100 rem.

(*b*) An accumulated total dose equivalent to the hands and forearms not to exceed 300 rem.

(2) *Protecting property, controlling effluents, or controlling fires.* In situations where human life is not threatened, but in which protection of property, control of effluents, or control of fires is essential, the OSC/NAICO may authorize emergency exposure of any individual, 19 years of age or older, to the following levels:

(*a*) An accumulated whole body dose equivalent not to exceed 25 rem.

(*b*) An accumulated total dose equivalent to the hands and forearms not to exceed 100 rem.

c. Reporting Requirements. Emergency exposures to ionizing radiation must be reported to the nearest regional office of the Nuclear Regulatory Commission (NRC), if established limits are exceeded—

(*a*) Exposures exceeding 5 rem whole body radiation must be reported to NRC within 24 hours.

(*b*) Exposures exceeding 25 rem whole body radiation must be reported to NRC immediately by telephone or by telegraphic means. See Title 10, Part 20 for additional information.

d. Film Badges. Film badges will be used as the basis for the official radiation dose records of personnel involved in nuclear accident contamination control. If film badge development service is not provided with the site logistical support, the team leader of each emergency team will insure that the film badges are processed and that the results are recorded in accordance with AR 40–14. Film badge service may be obtained from Lexington Blue Grass Army Depot, Lexington, Kentucky 40507, or Sacramento Army Depot, Sacramento, California 95813, in accordance with SB 11–206.

*One rem (roentgen equivalent mammal) is the quantity of ionizing radiation of any type which, when absorbed by man or other mammal, produces a physiological effect equivalent to that produced by the absorption of 1 roentgen of X-ray or gamma radiation.

CHAPTER 11

DECONTAMINATION

11–1. General

Emergency teams normally will not undertake large-scale decontamination operations. However, they may be required to provide advice and supervision of decontamination operations. Decontamination methods will vary according to the amount and type of contamination present.

11–2. Considerations

There are several factors that should be considered when decontamination operations are required.

a. The hazards of radiation can be decreased by allowing the material to decay or by covering the contamination. The radiation hazard can be eliminated in a certain area by transporting the contamination to a new location. Generally, short half-life emitters are allowed to decay, whereas the longer half-life emitters are covered or removed.

b. The nature of the surface of the contaminated area or item will determine the decontamination method to be used.

c. Optimum effective decontamination will start with the simplest method. More complicated methods can then be attempted to reduce the remaining contamination.

d. Decontamination normally will be performed from the lowest level of contamination to the highest level.

e. Decontamination of personnel will normally receive priority.

11–3. Principles

The three general principles of radiological decontamination are removal, sealing, and aging. The use of a combination of methods derived from these principles may produce the best results (TM 3–220).

a. Removal is effective for all types of contamination and is used in the majority of cases where time is the limiting factor. Table 11–1 is a summary of removal methods for decontamination of various surfaces. Table 11–2 provides guidance on the efficiency of certain removal methods.

(1) Advantages of removal are that it—

(*a*) Provides, in certain cases, a relatively rapid means of decontamination.

(*b*) Permits early restoration of equipment and material.

(2) Disadvantages are that it—

(*a*) Requires a large number of individuals.

(*b*) Requires considerable equipment and supplies.

(*c*) Produces a radioactive waste disposal problem.

b. Sealing is very effective against alpha contamination and should be used when this is the only radiation hazard present.

(1) Advantages of sealing are that it—

(*a*) Provides, in certain cases, a relatively rapid and inexpensive means of decontamination.

(*b*) Permits re-use of contaminated equipment and supplies.

(2) Disadvantages are that it—

(*a*) May require an extensive effort.

(*b*) Does not provide a practical means for attenuation of gamma contamination because of the quantity of material required.

(*c*) Requires periodic checks to insure that any sealing material used has not deteriorated.

(*d*) Will require control of use of area to insure that activities do not destroy sealer.

d. Aging depends on the natural decay rate of the radioactive material and is very effective for short half-life emitters. It is the ideal method when time is unlimited.

(1) Advantages of aging are that it—

(*a*) Does not require personnel.

(*b*) Reduces all radioactivity to some degree.

(2) Disadvantages are that it—

(*a*) Proves ineffective for contaminants with long half-lives because an extended period of time is required.

(*b*) Imposes limited access security measures.

(*c*) Precludes early usage of the contaminated area and equipment.

Table 11–1. Removal Methods for Decontamination of Various Surfaces

Method	Surface	Action	Technique	Advantages	Disadvantages
VACUUM CLEANING.	Dry surfaces	Removes contaminated dust by suction.	Use conventional vacuum technique with efficient filter.	Good on dry porous surfaces. Avoids water reactions.	All dust must be filtered out of exhaust. Machine is contaminated.
Water	All nonporous surfaces (metal, painted, plastic, etc.).	Dissolves and erodes.	Hose with high pressure water at an optimum distance of 15 to 20 feet. Spray vertical surfaces at an angle of incidence of 30° to 45°; work from top to bottom to avoid recontamination. Work from upwind to avoid spray. Determine cleaning rate, experimentally, if possible; otherwise, use a rate of 4 square feet per minute.	All water equipment may be utilized. Allows operation to be carried out from a distance. Contamination may be reduced by 50%. Water equipment may be used for solutions of other decontaminating agents.	Drainage must be controlled. Not suitable for porous materials. Oiled surfaces cannot be decontaminated. Not applicable on dry contaminated surfaces (use vacuum); not applicable on porous surfaces such as wood, concrete, canvas. Spray will be contaminated.
STEAM	Nonporous surfaces (especially painted or oiled surfaces).	Dissolves and erodes.	Work from top to bottom and from upwind. Clean surface at a rate of 4 square feet per minute. The cleaning efficiency of steam will be greatly increased by using detergents.	Contamination may be reduced by approximately 90% on painted surfaces.	Steam subject to same limitations as water. Spray hazard makes the wearing of waterproof outfits necessary.
DETERGENTS	Nonporous surfaces (metal, painted, glass, plastic, etc.).	Emulsifies contaminant and increases wetting power of water and cleaning efficiency of steam.	Rub surface 1 minute with a rag moistened with detergent solution; then wipe with dry rag; use clean surface of the rag for each application. Use a power rotary brush with pressure feed for more efficient cleaning. Apply solution from a distance with a pressure proportioner. Do not allow solution to drip onto other surfaces. Moist application is all that is necessary.	Dissolves industrial film and other materials which hold contamination. Contamination may be reduced by 90%.	May require personnel contact with surface. May not be efficient on long-standing contamination.

Table 11–1. Removal Methods for Decontamination of Various Surfaces—Continued

Method	Surface	Action	Technique	Advantage	Disadvantages
COMPLEXING AGENTS: Oxalates Carbonates Citrates.	Nonporous surfaces (especially unweathered surfaces; i.e., no rust or calcareous growth).	Form soluble complexes with contaminated material.	Complexing agent solution should contain 3% (by weight) of agent. Spray surface with solution. Keep surface moist for 30 minutes by spraying with solution periodically. After 30 minutes, flush material off with water. Complexing agents may be used on vertical and overhead surfaces by adding chemical foam (sodium carbonate or aluminum sulfate).	Holds contamination in solution. Contamination may be reduced by 75% in 4 minutes on unweathered surfaces. Easily stored; carbonates and citrates are nontoxic, noncorrosive.	Requires application for 5 to 30 minutes. Little penetrating power; of small value on weathered surfaces.
ORGANIC solvents.	Nonporous surfaces (greasy or waxed surfaces, paint or plastic finishes, etc.).	Dissolves organic materials (oil, paint. etc.)	Immerse entire unit in solvent or apply by wiping procedure (see DETERGENTS).	Quick dissolving action. Recovery of solvent possible by distillation.	Requires good ventilation and fire precautions. Toxic to personnel. Material bulky.
INORGANIC ACIDS.	Metal surfaces (especially with porous deposits; i.e., rust or calcareous growth); circulatory pipe systems.	Dissolves porous deposits.	Use dip-bath procedure for movable items. Acid should be kept at a concentration of from 1 to 2 normal (9 to 18% hydrochloric, 3 to 6% sulfuric acid). Leave on weathered surfaces for 1 hour. Flush surface with water, scrub with a water-detergent solution, and rinse. Leave in pipe circulatory systems 2 to 4 hours; flush with plain water, a water-detergent solution, then again with plain water.	Corrosive action on metal and porous deposits. Corrosive action may be moderated by addition of corrosion inhibitors to solution.	Personnel hazard. Wear goggles, rubber boots, gloves, and aprons. Good ventilation required because of toxicity and explosive gases. Acid mixtures should not be heated. Possibility of excessive corrosion if used without inhibitors. Sulfuric acid not effective on calcareous deposits.
ACID MIXTURES: Hydrochloric Sulfuric	Nonporous surfaces (especially with porous deposits); circula-	Dissolves porous deposits.	Same as for inorganic acids. Mixture consists of 0.1 gal.	Contamination may be reduced by 90% in 1 hour (unweathered	Weathered surfaces may require prolonged treatment. Same

Table 11-1. Removal Methods for Decontamination of Various Surfaces—Continued

Method	Surface	Action	Technique	Advantage	Disadvantages
Acetic Acid Citric Acid Acetates Citrates.	tory pipe systems.		hydrochloric acid, 0.2 lb sodium acetate, and 1 gal. water.	surfaces). More easily handled than inorganic acid solutions.	safety precautions as required for inorganic acids.
CAUSTICS: Lye (sodium hydroxide) Calcium hydroxide Potassium hydroxide.	Painted surfaces (horizontal).	Softens paint (harsh method).	Lye paint-removal solution: 10 gal. water, 4 lb lye, 6 lb boiler compound, 0.75 lb cornstarch. Allow lye paint-remover solution to remain on surface until point is softened to the point where it may be washed off with water. Remove remaining paint with long-handled scrapers.	Minimum contact with contaminated surfaces. Easily stored.	Personnel hazard (will cause burns). Reaction slow; thus, it is not efficient on vertical or overhead surfaces. Should not be used on aluminum or magnesium.
Trisodium phosphate.	Painted surfaces (vertical, overhead).	Softens paint (mild method).	Apply hot 10% solution by rubbing and wiping procedure (see DETERGENTS).	Contamination may be reduced to tolerance in one or two applications.	Destructive effect on paint. Should not be used on aluminum or magnesium.
ABRASION ------	Nonporous surfaces.	Removes surface-	Use conventional procedures, such as sanding, filing, and chipping; keep surface damp to avoid dust hazard.	Contamination may be reduced to as low a level as desired.	Impracticable for porous surfaces because of penetration by moisture.
Sandblasting ----	Nonporous surfaces.	Removes surface-	Keep sand wet to lessen spread of contamination. Collect used abrasive or flush away with water.	Practical for large surface areas.	Contamination spread over area must be recovered. Contaminated dust is personnel hazard.
Vacuum blasting-	Porous and nonporous surfaces.	Removes surface; traps and controls contaminated waste.	Hold tool flush to surface to prevent escape of contamination.	Contaminated waste ready for dispersal. Safest abrasion method.	Contamination of equipment.

Table 11-2. Typical Decontamination Efficiencies

Material	Vacuum cleaning	High pressure water	High pressure water plus detergent	Sand-blasting	Steam cleaning
Glass	98	98	100	100	97
Painted wood	99	98	99	100	91
Asphalt	72	92	98	92	22
Concrete	74	98	96	100	27
Unpainted wood	36	85	99	99	85

11-4. Personnel Decontamination

a. General. If the accident site is contaminated, a personnel monitoring station should be established for personnel leaving the contaminated area. Military personnel will decontaminate themselves. Civilians who are contaminated will be advised to change clothing and place the contaminated clothing in a bag for decontamination. After removing contaminated clothing, they should take a shower and be remonitored. All water used in the decontamination process must be collected and stored in metal containers. If contaminated females are present, arrangments will have to be made to process them separately from the males or provide separate decontamination facilities.

b. Alpha Monitoring. Monitoring is performed to detect contamination on the body, to serve as a guide for decontamination, and to identify potential internal hazards. Monitoring of individuals for alpha contamination is very slow and difficult; emergency team personnel working in contaminated areas may make only a cursory monitoring of individuals if routine procedures require decontamination and change of clothing. Results of alpha monitoring in the rain may be misleading because of attenuation by the moisture present.

(1) *Equipment.* The selection and correct use of proper instruments is essential. Radiacmeters equipped with separate probes and earphones are used for monitoring of personnel.

(2) *Procedures.* A complete and careful check must be made of those parts of the body and clothing most susceptible to contamination. A systematic sequence should be followed; for example, monitoring the hands first, then monitoring the face and head, and proceeding down the body to the feet ((*d*) below).

(*a*) The use of earphones results in easier and more accurate monitoring. The monitors can watch the probe so that it will not become contaminated and can hear an audible response if contamination is present. The IM-170/PD gives an immediate aural response for low levels of radiation, which considerably lessens the monitoring time.

(*b*) The probe should be held close to the surface being monitored and moved with a slow, steady motion. The distance from the surface should be 2 to 3 centimeters for beta-gamma contamination. The probe should be placed directly on the surface for alpha contamination.

Note. If earphones are not used, the AC-3 probe must be held at each location for a period of from 4 to 6 seconds to allow sufficient time for the gauge to respond.

(*c*) Personnel being monitored should stand on a pad or platform located in the contamination reduction area. The person should be instructed to stand with feet spread apart about 30 centimeters (approximately 1 foot) and arms extended sideward with palms up and fingers straight.

(*d*) Steps to be followed are listed below:

1. Monitor both hands and forearms with palms up; repeat with hands and arms turned over.

2. Monitor the entire front of the body, starting at the top of the head. Check the forehead, nose, mouth, neckline, torso, knees, and ankles thoroughly. Have the person turn around; repeat the procedures from head to ankles.

3. Have the person raise one foot; monitor the sole. Repeat the procedure for the other foot.

(*e*) Wounded personnel should be monitored under the supervision of, or by, medical personnel. Contamination should be a secondary consideration if the wounds require immediate medical attention. Corpsmen and medical attendants treating the wounded should be monitored frequently to prevent them from contaminating others and their medical supplies and equipment.

(*f*) If contamination is found in excess of the acceptable emergency remaining contamination levels indicated in table 11-3, decontamination will be required. If no contamination is detected, no further action is required.

c. Decontamination in the Field.

(1) Establishment of a temporary personnel decontamination station may be necessary. If so, it should be located where entry into and exit from the contaminated area takes place. This station should include—

(*a*) Containers for waste materials.

(*b*) Containers for contaminated clothing.

(*c*) Swabs and masking tape for removing hot spots.

(*d*) Containers of soapy water.

(*e*) Containers of rinse water.

(*f*) Towels and supply of clothing.

(*g*) Radiac instruments.

(2) Persons coming from the contaminated area will be initially monitored upon entering the contamination control station. They will then remove outer clothing consisting of boot covers, gloves, respirator, coveralls, and surgeon's caps. Any hot spots will be cleaned with swabs or masking tape to reduce spread of contamination.

(3) After washing with soapy water and rinsing, individuals must be thoroughly dry before being remonitored at the contamination control line, since water will shield alpha particles.

d. Detailed Procedures. If decontamination is not fully effective, the following techniques will be used for each specific area:

(1) *Body and skin.*

(*a*) Spot-clean hot spots, using swabs and masking tape. Remonitor to determine effectiveness.

(*b*) Wash the entire body, hair, and hands, using soap lather and plenty of hot water. Clean fingernails. Do not use abrasive or highly alkaline soaps or powders. Be sure not to puncture or abrade skin through excess scrubbing in any of these procedures.

(*c*) If soap lather is not effective, use the following materials which can normally be procured from local sources or the nearest medical facility.

1. A water paste mixture of 50 percent powdered detergent and 50 percent cornmeal. Massage with this mixture for 5 minutes and then rinse thoroughly with water.

2. A 5-percent water solution of a mixture of 30 percent detergent, 65 percent Calgon or other water softener, and 5 percent Carbose (carboxylmethyl cellulose). Apply, rub vigorously for 1 minute, and then rinse thoroughly with water.

3. A preparation consisting of 8 percent Carbose, 2 percent detergent, 1 percent Versene, and 88 percent water homogenized into a cream. Apply as a skin cleanser, without water, and then wipe off.

4. Waterless cleanser used by automobile mechanics.

(2) *Hands.* Use soap lather and rinse. Clean fingernails. If contamination still remains after two attempts, apply mixtures listed in (1)(*c*) above as required. In some cases, wearing surgeon's rubber gloves for a period of approximately 30 minutes will cause sufficient sweating to remove contamination.

(3) *Hair.*

(*a*) Wash hair several times. Repeat until decontamination has been effected or until further washings will obviously be ineffective.

(*b*) If contamination is not lowered to acceptable levels, shave the head and apply skin decontamination methods to the scalp.

(4) *Wounds.* Wounds will be treated by such first-aid measures as appropriate without consideration of contamination. If alpha contamination is found on other parts of the body when monitored, assume that wounds are alpha contaminated. After applying first aid, refer the casualty to medical personnel to determine the appropriate priority of action.

e. Evaluation. Upon completion of decontamination procedures, personnel should be monitored again to insure that the levels shown in table 11-3 are not exceeded (para 11-8). If these levels are still exceeded, medical assistance should be requested. Any surface being monitored for the presence of alpha contamination must be completely dry because water will shield residual contamination.

11-5. Clothing and Launderable Equipment Decontamination

a. Launderable equipment items can be placed in an automatic washing machine and laundered without damage to the equipment or the washing machine. Contaminated wash water should be collected for disposal in accordance with Title 10, Code of Federal Regulations, Part 20, and AR 755-15.

b. Those items that are contaminated above acceptable levels and that do not show any appreciable contamination reduction after three successive launderings should be disposed of as radioactive waste. Exceptions may be made if decay is likely to reduce the contaminants to the acceptable levels shown in table 11-3 (para 11-8) within a reasonable time and if security and storage requirements are economically feasible.

c. Automatic washing machines should be clean and free of soap scum to prevent deposition of contamination. If decontaminating agents (TM 3-220 and *d* below) are used, they will aid in keeping washers free of contamination.

d. Laundering involves seven operations of 5 minutes each, using hot water (120° to 140°F.) and additives as indicated below:

(1) First wash—detergent.

(2) Second and third washes—citric acid.

(3) Fourth and fifth washes—chelating agent, such as Versene.

(4) Sixth and seventh washes—water rinses.

e. After the decontaminated items have been laundered and completely dried, they must be checked for any remaining contamination.

f. Contaminated clothing should be laundered only at an approved decontamination facility.

11–6. Equipment Decontamination

a. If the removal method of decontamination is attempted on items that are contaminated to high beta-gamma levels, excessive personnel exposures may result. Natural decay may reduce the contamination to reasonable working levels.

b. The sealing method will not be normally used except for alpha contamination; it should be used only after removal methods have not been adequate.

c. Five general methods by which surface contamination may be removed or reduced are as follows:

(1) Brushing or vacuum cleaning.

(2) Washing, soaking, or scrubbing with hot or cold water. Soap, detergents, or chelating agents may be used.

(3) Steam cleaning.

(4) Cleaning with solvents.

(5) Removing surface by using chemicals, abrasives, sandblasting, grinding, or electrolysis. (Care must be exercised to preclude inhalation of contaminated residue.)

For details on employing these methods, see TM 3-220. These methods will result in contaminated runoff and residue which must be controlled and disposed of according to DOD and ERDA directives for contaminated waste.

d. The simplest removal methods will be tried first and then followed by the more difficult methods. Each method will be tried at least twice before a different method is used.

e. After an item has been monitored, an appropriate decontamination method will be selected and the necessary steps performed; then the results will be evaluated by remonitoring. This procedure will be repeated until the contamination is within acceptable levels. The following details for specific items are furnished:

(1) *Vehicles.*

(*a*) If vehicles are required within a contaminated area, consideration should be given to using the same vehicles and keeping them in the contaminated area until completion of recovery operations. This will reduce the decontamination workload and the replacement costs.

(*b*) The highest levels of contamination usually will be under fenders, on the undercarriage where lubricants are exposed, on wheels and tires, and inside where tracked into a vehicle. When liquids are used for decontaminating, procedures should be started at the top.

(*c*) Weather-cracked tires are difficult to decontaminate. Disposal of contaminated tires may be necessary.

(2) *Radiacmeters.*

(*a*) A low level of contamination can be allowed when instruments are being used in monitoring for high levels of contamination. The initial reading is noted and subtracted from any subsequent readings.

(*b*) Contamination of the instrument may be determined by removing it from the contaminated area and checking the reading. Any reading above normal background indicates contamination of the instrument. Alpha instrument contamination can be determined within an alpha contaminated area by holding the sensitive detecting probe 30 centimeters (approximately 1 foot) or more away from all surfaces and noting the meter reading. The meter needle should indicate background, and only background clicks should be heard with the headset if the instrument is not contaminated.

(*c*) Extreme care is necessary to avoid damaging the shields or probes when decontaminating alpha instruments. Most radiacmeters can be decontaminated by wiping the exterior surfaces with a damp cloth or sponge. Contamination can also be removed by running water under low pressure over the surface. Care must be taken to prevent water from entering the probe where it can short out the electronic circuits. With gas flow devices such as the AN/PDR-54, operating the gas flow valve in the FLUSH position will help to keep the water being used out of the probe. A less effective means of decontamination is to wipe the probe gently with clean cotton or a camel's hair brush. The adhesive surface of masking tape provides an effective means of decontaminating the instrument probe. If the probe cannot be decontaminated using these methods, the probe face should be changed.

(3) *Miscellaneous items.*

(*a*) Moistureproof protective clothing, rubber boots, and similar items can usually be effectively decontaminated by showering, washing, or hosing prior to removal.

(*b*) Canvas, rope, and similar coarse materials readily absorb contaminants which have a tendency to imbed deeper into the materials when liquids are used. Dry brushing or vacuum cleaning is the most suitable technique for such materials. If these procedures prove ineffective, the items may be allowed to age or may be disposed of if alpha or other long-lived emitters are involved.

f. When items are soaked, washed, or scrubbed with liquids other than water or with liquids containing soap, detergents, or solvents, clear water will be used as a final rinse.

g. If a power-driven decontaminating apparatus (PDDA) or other shower system is used, adequate drainage systems must be provided prior to use to insure that contaminated waste water is controlled.

11–7. Terrain Decontamination

a. Definitions. The following definitions are to be applied to terrain decontamination.

(1) *Acute hazard area.* The cloud from a nuclear weapon high-explosive detonation contains radioactive dust and debris which falls out as the cloud passes. The area over which this cloud passes is the acute hazard area.

(2) *Chronic hazard area.* The land surface area upon which alpha contamination greater than 3,500 μg $^{239}Pu/m^2$ remains after the passage of the radioactive cloud following a high-explosive detonation is a chronic hazard area. This contamination continues to prevent a chronic hazard to personnel in varying degrees until decontamination can be accomplished.

(3) *Hazard area.* An area upon which alpha contamination is greater than 1,000 cpm ^{239}Pu.

(4) *Hot spot.* The region in a contaminated area in which the level of radioactive contamination is considerably greater than in neighboring areas is a hot spot. Hot spots may be found in isolated or widely separated locations within and possibly outside the area of contamination. The location of hot spots cannot be accurately predicted.

b. Alpha Contamination. Alpha contamination will be decontaminated as prescribed by Federal law. This depends upon occupancy, use, and other related factors. The method chosen will depend on the following factors:

(1) Radiation level.
(2) Size of area.
(3) Type of surface.
(4) Location.
(5) Cost.

In addition, prime consideration must be given to the possibility of alpha contamination resuspension.

c. Priorities. When dealing with alpha contamination, the chronic hazard areas will require considerable attention and perhaps prolonged decontamination action. The chronic or long-term hazard is due to resuspension of alpha contamination from the ground. Alpha contamination is not a significant hazard as long as it does not become airborne. The important factors are the degree of contamination and the extent to which the material is bound to the surface. For example, a 1,000 μg $^{239}Pu/m^2$ deposit of loosely bound material is more a hazard than the same level of fixed material. Therefore, the degree of contamination should be reduced as much as posible by decontamination consistent with reasonable efforts and cost in the following priority:

(1) *First priority* for decontamination should be assigned to chronic hazard areas and areas in which heavy contamination can readily become airborne. If these areas are solely within a nonessential or an unpopulated area, decontamination may be deferred in the interest of rendering assistance or carrying out damage control actions in populated areas or in those areas considered essential to the mission. However, if decontamination is to be deferred in the chronic hazard area, action must be taken to fix the contamination within the chronic hazard contour line to prevent its airborne movement.

(2) *Second priority* for decontaminating should be assigned to areas of contamination with less than 3,500 μg $^{239}Pu/m^2$ but more than 1,000 μg $^{239}Pu/m^2$. A serious health hazard will not result if there is a lapse of a day or two before starting decontamination of these areas. However, if the area of contamination encompasses a heavily populated area, expeditious action may be warranted in the public interest.

(3) *Third priority* for decontamination should be assigned to areas where the contamination is less than 1,000 μg $^{239}Pu/m^2$. Decontamination of such areas will be accomplished if re-

duction of contamination is possible and is consistent with reasonable cost and effort. Decontamination is not mandatory in all cases; a decision to decontaminate such areas will be based upon an evaluation of the individual situation and should consider cost, morale factors, and potential liability claims against the Government. Hospitals, food facilities, nurseries, and similar places should be decontaminated to essentially normal background levels whenever possible. In general, populated areas should be decontaminated to normal background levels whenever possible. Assistance from Interagency Radiological Assistance Teams or civilian organizations may be necessary to accomplish large-area decontamination in populated areas. Coordination with community public health authorities should be made to insure that civilian requirements are met.

d. Immediate Temporary Action. Immediately upon determination and plotting of the contamination contours, it is best to fix temporarily all levels above 1,000 μg $^{239}Pu/m^2$. Spraying with water or with oil as a temporary "fixing" agent is sufficient to minimize the airborne resuspension hazards. Spraying operations should be controlled closely to prevent an accumulation of runoff water. A fine, misty airborne spray will best remove airborne particles as well as "fix" the soil surface or pavement contamination. Firetrucks are capable of providing such a spray.

e. Methods. Procedures used for terrain decontamination will be based on methods of sealing or of removing the contaminant. TM 3–220 and TM 5–225 give details of area decontamination.

(1) *Fixing.* Fixing is an excellent procedure that will inexpensively eliminate the hazard presented by the contaminant. Certain factors must be considered when employing fixing as a decontamination procedure. Fixing is unsuitable when there is a possibility that the contaminant may be uncovered and resuspended. Area exclusion must be maintained, and periodic monitoring must be performed to insure that the contamination remains fixed. Several fixing procedures are described below. These methods are suitable on government controlled land with proper sanctions, but may not be suitable on state or private lands. Coordination must be made with environmental and Public Health agencies.

(*a*) *Paving with asphalt or concrete.* Pav- ing provides a permanent sealing of the conta- minant (100 percent efficient) but is quite ex- pensive when large areas are involved.

(*b*) *Plowing.* Plowing to a depth of abou 30 centimeters (12 inches) will adequately mi and bury the contaminant (98 percent efficient)

(*c*) *Oiling.* Spreading a rapid cure oil ove the area will form a semihardened surfac within 24 hours (89 percent efficient).

(*d*) *Flooding with 1 inch of water.* Floodir accelerates natural weathering action ar leaches the contaminant into the surface (8 percent efficient). Caution should be exercise since there is the possibility of contaminatir the water table.

(2) *Removal.* Terrain decontamination removal consists of removing the top 5 ce timeters (2 inches) of the soil and hauling away for burial. The soil should be semifixe with water or oil prior to this operation to pr vent airborne resuspension. This procedure quite expensive as considerable equipment ar manpower are involved, and care must be take to prevent accidental contamination spread du ing transportation of the removed contaminan

f. Other Contamination. Other types radioactive contamination must be evaluat according to the hazard presented and deco tamination accomplished to reduce this haza to a safe level. The determination of a safe lev is dependent on the particular contaminar Other than alpha emitters, the only predictab contamination likely to be encountered is fissi fragments.

g. Evaluation. A complete remonitoring a evaluation of the accident area must be und taken at 1-month, 6-month, and yearly postac dent intervals. In addition to the radiac inst ment measurements, soil, water, air, and propriate vegetation and biota samples sho be collected and evaluated.

11–8. Levels of Contamination

a. Any radiological contamination should reduced to the lowest level practicable by dec tamination procedures. These procedures usually result in a reduction and not in compl decontamination of residual contamination.

b. Acceptable Emergency Remaining C tamination Levels (Alpha Team Instrumer

Table 11–3. Acceptable Emergency Remaining Contamination Levels (Alpha Team Instrumentation)[1]

Item	Acceptable Emergency Remaining Contamination Level Following Decontamination[2]	
	Beta-Gamma[3] (mrad/hr) at 2.5 cm (1 inch)	Alpha (cpm)
SKIN[4].		
Body	0.1	600
Hands	0.3	1,200
CLOTHING		
Personnel	0.2	600
Protective	2.0	3,000
Respirators	1.0	600
CONTAINERS	0.3	600
VEHICLES[5].		
For operation in the radiation area.	2.0	11,000
For operation outside of the radiation area.	0.5	1,200

[1] The levels in this table are emergency levels only. All personnel, objects, and te[illegible]n must be remonitored by the RADCON team upon its arrival.

[2] [illegible] are average meter readings. At these low levels there will be considerable in[illegible]r drift rather than a steady indication of the reading. Consequently, monito[illegible]ust estimate the average reading obtained. Readings that average higher than these acceptable limits indicate a need for further decontamination effort.

[3] Beta-gamma measurements will be made through not more than 7 milligrams per square centimeter total absorber.

[4] All contaminated wounds must be treated by medical personnel.

[5] Vehicles to be released for public use must have no detectable activity.

tion) (table 11–3) have been established to furnish practical guidelines for Alpha team monitoring of emergency decontamination efforts. These levels are NOT permissible contamination levels, and are valid only until the RADCON team is available to remonitor personnel, materiel, and terrain.

c. Permissible Contamination Levels will be determined on-site by Department and Agency level personnel (e.g., ERDA, DNA, DA, DAF, DN) after consideration of current established permissible levels, radiological threat, site characteristics, and other considerations. Monitoring of personnel, materiel, and terrain for attainment of permissible levels will be under the direct supervision of the RADCON team.

CHAPTER 12

RADIOACTIVE WASTE DISPOSAL

WARNING

Movement of any amount of plutonium by air is prohibited. Radiac check and calibration sources containing plutonium will not be moved by air. Medical items for individual patients are exempt.

12-1. General

Radioactive waste includes any material which is radioactive, or which is contaminated with radioactive material, and which is no longer of use to the possessing agency.

12-2. Classification of Radioactive Waste

One method of classifying radioactive waste is by physical form.

a. Solid Waste. Solid waste includes such material as contaminated equipment and contaminated trash (to include surface layer of ground contaminated from a nuclear accident).

b. Liquid Waste. Liquid waste will usually be of low level contamination and may be produced in large amounts from decontamination operations and some laboratory operations. With proper dilution as outlined in Title 10, Code of Federal Regulations, Part 20, paragraph 20.303, liquid contamination may be disposed of in a sewerage system. Checks should be made with EPA, Public Health, state and local agencies prior to use of this method.

c. Gaseous Waste. Gaseous waste normally will not require decontamination and disposal, as it will be diluted by dispersion in the air.

12-3. Responsibilities

a. The Surgeon General is responsible for providing advice, guidance, and medical assistance on the health hazards associated with and resulting from the disposal of unwanted radioactive materials (AR 755-15).

b. The Commander, Edgewood Arsenal, Aberdeen Proving Ground, Maryland, is responsible for exercising staff supervision over all matters pertaining to the disposal of radioactive material within the Department of the Army.

c. Installation and activity commanders having radioactive material for disposal are responsible for providing adequate security, storage, and monitoring services. For detailed instructions, refer to AR 755-15, TM 3-220, TM 3-260, and TM 5-225.

12-4. Packaging, Labeling, and Shipping Radioactive Waste

a. Packaging Instructions.

(1) Returnable amounts of source and special (SS) nuclear material from special weapons will be packaged for surface movement and labeled in accordance with TM 9-1185-220, and shipped in accordance with appropriate EOD manuals and appropriate Department of Transportation (DOT) regulations. ERDA representatives will be available to assist in packaging and labeling.

(2) Radioactive waste such a paper, clothing, and dirt contaminated from a nuclear accident will be packaged for surface movement, labeled, and shipped to a radioactive material disposal facility for ultimate disposal. The radioactive waste normally will consist of large amounts of dirt and other material and will be packaged in accordance with TM 55-315. If DOT regulations cannot be complied with, application for waiver must be made in accordance with AR 55-55.

(*a*) Radioactive materials that present special hazards because they tend to remain fixed in the human body for long periods of time (radium, plutonium, strontium, etc.) or any liquid waste materials must be packed inside leakproof containers. The design and preparation of the package must be such that there will be no significant radioactive surface contamination of any part of the container.

(*b*) All outside containers must meet DOT and AR 55-55 container requirements.

(*c*) To meet the above requirements, 55-gallon drums or garbage cans may be used if provision is made for sealing the containers prior to shipment for ultimate disposal. One

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method of sealing is to place a layer of concrete inside the can or drum. This may be done by using a mold in which to pour concrete. The concrete should be from 2.5 to 5 centimeters (1 to 2 inches) thick on the top, bottom, and sides of the container. The concrete will probably provide enough shielding to reduce the dose rate on the container surface below 200 mrad/hr.

b. Labeling Instructions. When radioactive material is shipped by common carrier, labeling will conform to DOT regulations contained in AR 55-55.

c. Shipping Instructions. Shipping instructions will be requested from Commander, Edgewood Arsenal, ATTN, SAREA-TS-MM, Aberdeen Providing Ground, MD 21010.

d. Air or Water Shipments. Air or water shipments of radioactive waste should be made in accordance with AR 55-55

APPENDIX A

REFERENCES

A-1. Department of the Army Publications

AR 15-22	Nuclear Weapon Accident Investigation Board (CONUS).
AR 40-5	Health and Environment.
AR 40-13	Radiological Emergency Medical Teams (REMT)
AR 40-14	Control and Recording Procedures: Occupational Exposure to Ionizing Radiation.
AR 50-5	Nuclear Surety.
AR 55-55	Transportation of Radioactive and Fissile Materials Other Than Weapons.
AR 55-203	Movement of Nuclear Weapons, Nuclear Components, and Related Classified Nonnuclear Materiel.
AR 75-14	Interservice Responsibilities for Explosive Ordnance Disposal.
AR 75-15	Responsibilities for Explosive Ordnance Disposal.
AR 220-58	Organization and Training for Chemical, Biological, and Radiological (CBR) Defense.
AR 310-25	Dictionary of United States Army Terms.
AR 310-50	Authorized Abbreviations and Brevity Codes.
AR 360-5	Army Information, General Policies.
AR 360-43	Information Guidance—Nuclear Accidents and Nuclear Incidents.
AR 360-65	Establishment and Conduct of Field Press Censorship in Combat Areas.
AR 360-80	Release of Information When More Than One Service is Involved in Accidents or Incidents.
AR 385-30	Safety Color Code Markings and Signs.
AR 385-40	Accident Reporting and Records.
AR 700-52	Licensing and Control of Sources of Ionizing Radiation.
AR 700-64	Radioactive Commodities in the DOD Supply Systems.
AR 700-65	Nuclear Weapons and Nuclear Weapons Materiel.
AR 710-2	Materiel Management for Using Units, Support Units, and Installations.
AR 755-15	Disposal of Unwanted Radioactive Material.
FM 3-8	Chemical Reference Handbook.
FM 3-12	Operational Aspects of Radiological Defense.
FM 3-21	Chemical-Biological Accident Contamination Control.
FM 3-22	Fallout Prediction.
FM 9-14	Explosive Ordnance Disposal Service.
FM 9-15	Explosive Ordnance Disposal Unit Operations.
TM 3-220	Chemical, Biological, and Radiological (CBR) Decontamination.
TM 3-260	Operation of Radioactive Material Disposal Facilities.
TM 3-261	Handling and Disposal of Unwanted Radioactive Material.
TM 3-4240-204-14	Operator's Organizational, DS and GS Maintenance Manual: Mask, Chemical–Biological: Special Purpose, M9A1; Mask, Chemical-Biolog-

	ical: Special Purpose, M9 and Accessories
TM 3–4240–258–14	Operator's, Organizational, DS and GS Maintenance Manual: Mask, Chemical–Biological: Field, M17A1 and Accessories.
TM 3–6665–202–10	Operator's Manual: Calibrator, Radiac, TS–1230A.
TM 3–6665–203–10	Operator's Manual: Calibrator, Radiac, AN/UDM–6.
TM 5–225	Radiological and Disaster Recovery at Fixed Military Installations.
TM 5–315	Firefighting and Rescue Procedures in Theaters of Operations.
(SRD) TM 9–1185–220	Explosive Ordnance Disposal Procedures: Packaging Procedures for Nuclear and Contaminated Items Following Incident/Accident (U).
TM 9–1300–206	Ammunition and Explosives Standards.
TM 11–6665–208–15	Operator's, Organizational, Field, and Depot Maintenance Manual: Radiac Set AN/PDR–54.
TM 11–6665–209–15	Operator, Organizational, DS, GS and Depot Maintenance Manual Including Repair Parts and Special Tool Lists: Radiac Sets AN/PDR–27J, AN/PDR–27L, and AN/PDR–27Q.
TM 11–6665–213–12	Operator and Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radiacmeter IM–174/PD.
TM 11–6665–214–10	Operator's Manual: Radiacmeters IM–9E/PD, IM–93/UD, IM–93A/UD, and IM–147/PD.
TM 11–6665–221–15	Operator, Organizational, DS, GS, and Depot Maintenance Manual Including Repair Parts Lists: Radiac Set AN/PDR–60 (Eberline Instrument Corporation Portable Alpha Counter Model PAC–1SAGA)
TM 11–6665–232–12	Operator and Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radiacmeter IM–174A/PD.
TM 38–750	The Army Maintenance Management Systems (TAMMS).
TM 55–315	Transportability Guidance for Safe Transport of Radioactive Materials.
TB 385–2	Nucler Weapons Firefighting Procedures.
TB SIG 226–8	Chargers, Radiac Detector PP–1578/PD and PP–1578A/PD.
TB SIG 226–9	Field Expedient for Charging Radiacmeters IM–93/UD and IM–147/PD.
SB 11–206	Film Badge (Photodosimetry) Supply and Service for Technical Radiation Exposure Control.
CTA 50–900	Clothing and Individual Equipment (Active Army, Reserve Components, and DA Civilian Employees)

A–2. Other Publications

a. These publications are available by purchase from the Superintendent of Documents, US Government Printing Office, Washington, D. C. Requests should be submitted through local supply channels under the provisions of AR 710–2.

(1) Title 10, Code of Federal Regulations, Parts 19 and 20, Standards for Protection Against Radiation.

(2) Title 49, Code of Federal Regulations, Parts 171–179, Transportation of Explosives and Other Dangerous Articles.

(3) National Council on Radiation Protection and Measurements (NCRP) Reports:

(*a*) NCRP Report No. 10 (NBS Handbook No. 51), Radiological Monitoring Methods and Instruments.

(*b*) NCRP Report No. 22 (NBS Handbook No. 69), Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure.

(*c*) NCRP Report No. 30 (NBS Handbook No. 92), Safe Handling of Radioactive Materials.

b. Appropriate Nuclear Accident and Incident Control Plan (NAICP) or FORSCOM basic plan.

c. DOD Instruction 5100.2, Radiological Assistance Responsibilities in the Event of an Accident Involving Radioactive Material.

APPENDIX B

SAMPLE SOP OUTLINE

(Classification)

Headquarters

Location

Date

ANNEX————(ALPHA TEAM) TO NUCLEAR ACCIDENT CONTAMINATION CONTROL SOP

B-1. General

The purpose of this annex is to establish procedures for minimizing the possible hazardous effects or radioactive contamination resulting from a nuclear accident/incident and for performing expeditious decontamination of an accident site if required.

B-2. References

a. FM 3-15, Nuclear Accident Contamination Control.

b. Appropriate Nuclear Accident and Incident Control Plan (NAICP) or FORSCOM basic plan.

c. CTA 50-900, Clothing and Individual Equipment (Active Army, Reserve Components, and DA Civilian Employees).

B-3. Definitions

a. Alert—To inform or warn of a known or anticipated requirement, to enable alerted personnel or units to make certain preparations or assume a readiness posture that would permit movement or employment in less time than from a normal status, such as routeine duty, training, or off-duty.

b. On-call—A state of increased readiness as the result of an alert or warning order under which individuals may continue other activities (such as training or off-duty in quarters) but must be able to be contacted and must be able to report to their places of duty within a time specified by the commander.

c. Standby—Being at a designated duty location, in an advanced state of readiness for individual and organizational equipment and capable of performing appropriate duties or of deploying within the time and under the conditions prescribed by the commander.

d. On-scene commander (OSC)—A general officer who is dispatched by a major commander to command all emergency forces and direct all operations at a nuclear accident site.

e. Nuclear Accident/Incident Control Officer (NAICO)—A designated senior officer who, by knowldege and experience, is capable of making rapid and vital decisions and recommendations necessary to prevent or minimize the hazardous effects that can result from a nuclear accident.

f. Alpha Tean—A CBR team with the additional capability and responsibility for alpha monitoring. The team is also capable of limited personnel decontamination.

g. RADCON Team—Radiological Control Team.

(Classification)

(Classification)

B–4. Duties and Responsibilities

a. Team leader will—

(1) Prepare and maintain up-to-date information roster of all team members.

(2) Insure that each team member is aware of his assigned duties and is properly trained.

(3) Prepare a checklist to insure that the team on alert status can assemble, load equipment, and prepare to move out within 30 minutes during duty hours and within 1 hour during off-duty hours.

(4) Inform the OSC/NAICO as to the nature of the hazard upon arrival at the accident site and assist in controlling the spread of contamination.

b. Assistant team leader will assist the team leader and assume control if necessary.

c. Monitors will be capable of performing alpha and beta-gamma monitoring and survey procedures.

d. Each team member will be trained in his assigned duties as well as the duties of all other members, so in the event one member is unable to participate for any reason, any other member is sufficiently trained to perform his duties.

B–5. Warning System

The Alpha team will be alerted to assume an advanced readiness posture (either on-call or standby) when the movement of a nuclear weapon is scheduled. In the event of an accident, this team will be ordered to move to the accident site. At this time a backup Alpha team will be alerted to the standby readiness posture.

B–6. Capabilities

The Alpha team will be capable of—

a. Performing alpha and beta-gamma radiation monitoring.
b. Performing alpha and beta-gamma radiation surveys.
c. Supervising personnel and equipment decontamination.
d. Providing guidance to the OSC/NAICO on contamination control.
e. Assisting the RADCON team as required.

B–7. Procedures

The Alpha team will determine the presence or absence of radiological contamination. This determination must be made regardless of accident type.

a. Locate and mark the approximate perimeter of the contaminated area, using the following conditions as a guide for establishing the extent of the area:

(1) If significant beta-gamma radiation is present, mark the general location of the 10 mrad/hr dose rate.

(2) If alpha contamination is present, mark the general location of the 1,000 μg $^{239}Pu/m^2$ isodose line.

(3) Exclusion perimeter will be established from the locations determined in (1) and (2) above, using a combination of the locations farthest from the actual site of the accident.

(Classification)

(Classification)

b. Film badges and pocket dosimeters will be utilized at the accident site to control exposures to beta-gamma radiation.

c. Control will be established so that the total dose received by any individual exposed during recovery operations will not exceed 1.25 rem per calendar quarter from all sources of nuclear radiation. However, a larger dose may be permitted in order to save lives.

d. After operating at the site of a nuclear accident, persons will report to their servicing medical facility for evaluation of possible internal radiological contamination.

B–8. Protection

Personnel engaged in the initial area monitoring will wear respiratory protection, coveralls, gloves, surgeon's cap, and boot covers until the radiological contamination situation has been determined.

B–9. Decontamination

Only expedient emergency-type decontamination will be performed until the arrival of the RADCON team. Upon their arrival remonitoring will begin and detailed decontamination will be accomplished as directed by the OSC/NAICO. Acceptable emergency remaining contamination levels (table 11–3) will be observed.

a. Personnel. Contamination should be kept as low as possible. Persons leaving the contaminated area will be monitored; decontamination will be required whenever contamination is found on skin or clothing.

(1) Members of the military services will be required to decontaminate themselves.

(2) Civilians will be encouraged to be monitored for contamination. If contamination is found they will be advised to remove clothing, place it in a bag for decontamination, and to shower and return for further monitoring. When emergency decontamination has been accomplished they should be advised to put on clean clothing. Whether contaminated or not, all civilians who have been in the radiation area will be encouraged to furnish their name, address, and telephone number so that the RADCON team can contact them for followup monitoring.

b. Equipment. Vehicles and other equipment will be decontaminated as required. No item of equipment will be released from the CCS until it has been remonitored by the RADCON team.

c. Area and Building. The RADCON team will supervise necessary decontamination.

B–10. Supply

The Alpha team will be equipped to perform its mission and will be provided necessary protective clothing and equipment in accordance with CTA 50/900.

B–11. Training

All team members will be trained in alpha and beta-gamma monitoring and surveying.

a. Cross-training and periodic training in depth will be conducted to insure capability for performance of the team's mission.

b. Periodic practice alerts will be conducted to maintain readiness. These tests will consist of assembling the team and its equipment, moving to the site of a simulated accident, and conducting a survey.

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B-12. Records and Reports

Operational and administrative records will be maintained. Reports will be submitted in accordance with AR 385-40. Area maps and overlays will be kept current and the chronological sequence of events will be logged.

OFFICIAL: Command Line

(Classification)

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By Order of the Secretary of the Army:

FRED C. WEYAND
General, United States Army
Chief of Staff

Official:

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Distribution:

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