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# User's Manual for the PRM-470A Hand-Held Special Nuclear Material Monitor



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**User's Manual**  
for the  
**PRM-470A Hand-Held**  
**Special Nuclear Material Monitor**

**Paul E. Fehlau**



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## INTRODUCTION

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### **Purpose of the Manual**

This manual is for security inspectors who use a PRM-470A hand-held SNM monitor to search people, packages, and vehicles for radioactive material.

The manual is both a teaching tool and a handy reference. It acquaints first-time users with the search monitor and the proper techniques for searching. It is also a refresher for inspectors who have been reassigned to a search station. Finally, it serves as a reference at search stations by providing summaries and checklists.

This manual will

- acquaint you with the parts of your monitor
- examine the fundamentals of radiation
- explain how to operate the monitor, and
- recommend search techniques.

*Your manual is a  
handy reference.*



## **Searching for SNM**

One of your most important duties as a security inspector is to prevent unlawful removal of special nuclear materials (SNM) from access areas. Plutonium and enriched uranium qualify as SNM. The Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) require inspectors to search all persons, packages, and vehicles for these materials at exits from access areas.



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**Introduction (continued)**

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The search for SNM can be conducted with a hand-held monitor that detects radiation emitted by special nuclear materials. Although the greatest amount of radiation is gamma radiation, plutonium also emits neutrons. The PRM-470A monitor has a detector that is particularly sensitive to gamma-ray and neutron radiation. By using the monitor properly to conduct exit searches, you can detect even small quantities of plutonium and enriched uranium.

When the monitor senses radiation, it beeps more and more often as you move it toward radioactive material. This makes it possible for you to conduct a search by listening to the beeps. You do not have to watch the display. You will know you have located the radiation source when the monitor beeps most frequently.

It is relatively easy to detect a large quantity of radioactive material: the monitor senses it from a distance. Although it is not so easy to detect small quantities of radioactive material, they are just as important to find. Your monitor cannot sense a small quantity of radioactive material unless it is nearby. This means that you have to scan all surfaces, within a few inches, and take the time to do a thorough job.

A copy of this manual should be available at every search station.
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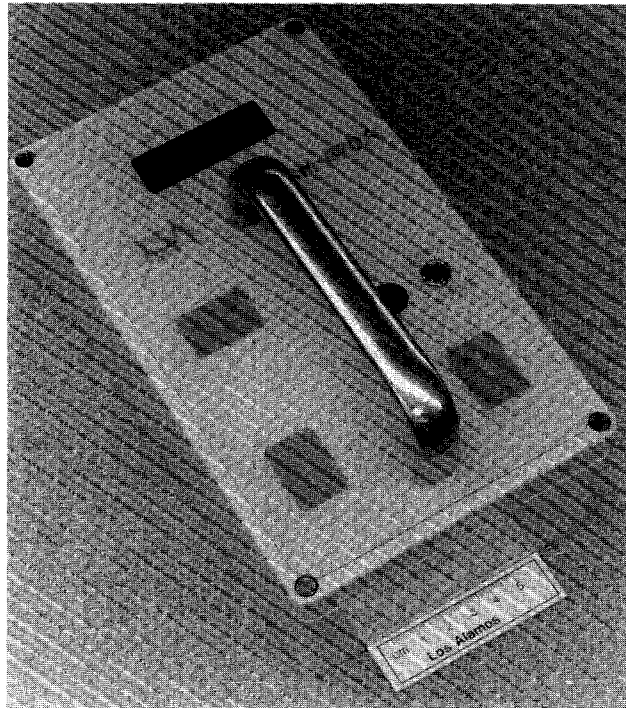
## YOUR PRM-470A SEARCH MONITOR

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### Detecting Radiation

Detecting radiation is the most effective way to search for hidden quantities of SNM. Although searching without a radiation monitor might meet the requirements of the DOE and the NRC, that kind of search is slow and may not always locate the nuclear material. Because all nuclear material is radioactive and emits radiation, searching with a PRM-470A monitor is a better way to find it.

The PRM-470A is a commercial instrument based on a programmable search monitor developed at the Los Alamos National Laboratory (LANL). The instrument is an improvement over earlier hand-held monitors, also developed at LANL, and it has found widespread use at nuclear facilities.





### **Description of the PRM-470A**

Your PRM-470A search monitor has a radiation detector inside it, along with electronics that operate the instrument. The radiation detector is located just under the display inside the case. Each monitor also contains a battery to power the electronics.

The compact and light-weight monitor is designed for hand use. The case and its contents weigh only 2.9 lb. For its size and weight, the monitor is highly sensitive.

The PRM-470A monitor can sense the low- intensity radiation, called background radiation, that is part of our natural environment. The monitor continuously counts pulses produced in its detector by radiation, and once each second it displays a new average count rate (counts per second) on its liquid crystal display (LCD). Natural background usually produces about 130 counts per second. An increase in radiation intensity, for example, one that is caused by a nearby radiation source, will increase the displayed result. However, don't watch the display to detect SNM (watching the display would divert your attention from searching). Instead, listen for beeps from the monitor to detect SNM.

To make it possible to detect small increases in count rate, the PRM-470A has a small computer that compares its measurements with a recorded background measurement. If the computer detects a significant intensity increase, it alerts you with a beeping sound. The closer you come to the source of radiation, the more beeps you will hear until the sound becomes continuous. Keep your eyes on the area that you are searching, and listen for beeps to discover or locate a source of radiation.

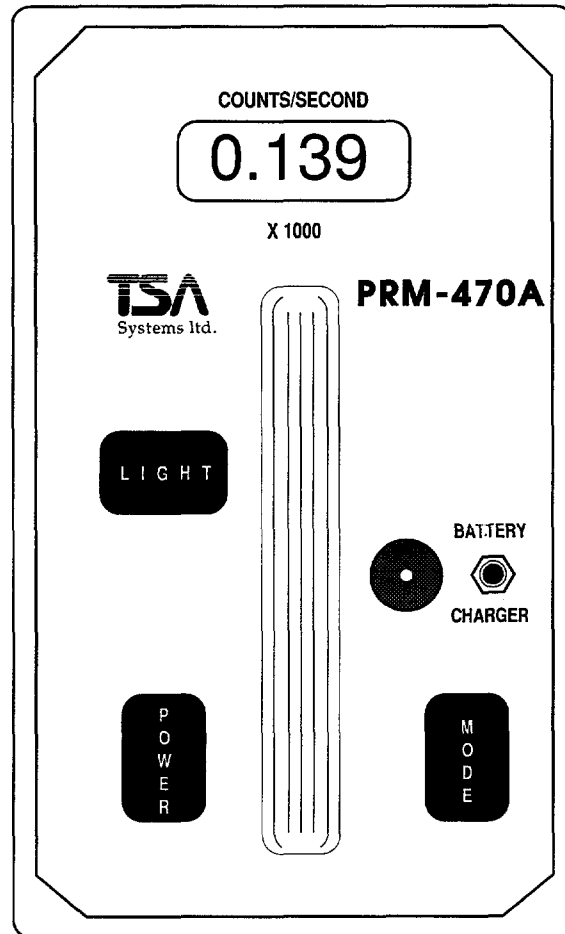
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## CONTROL PANEL FOR THE PRM-470A

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Grasp the PRM-470A firmly with one hand and hold it in front of you so that you can read the writing on the front panel. The sensitive front end of the monitor now points away from you, as it should during a search. Your interface with the PRM-470A is through the front panel. The following diagram and tables will familiarize you with its contents.

Sensitive end





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**Control Panel (continued)**

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These tables describe the function of the front panel components.


<b>Component</b>	<b>Operation</b>
 <b>POWER switch</b>	Turns the monitor on. If you do not see count rates being displayed, press the POWER. Pressing again turns power off
 <b>Operating MODE switch</b>	<p>The PRM-470A has two operating modes: a search mode that detects SNM and a background update mode. Your PRM-470A will have one of three software versions that use the MODE switch in the following different ways.</p> <p><i>Automatic Mode Version (V1.02)</i> This version allows you to update the background automatically. Pressing MODE causes the LCD to count from 9 down to 0 as background is measured. Then the monitor returns to the search mode. You know you have V1.02 if MODE causes a countdown from 9 to 0.</p>

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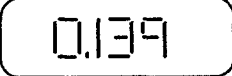



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Control Panel (*continued*)

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Component	Operation
 <p><b>Operating MODE switch</b> (cont)</p>	<p><i>Mode Swap Version (VI.00)</i></p> <p>This version uses MODE to change the PRM-470A operation from one mode to the other. So, if you are searching and need to update the background, you must</p> <ol style="list-style-type: none"><li>(1) press MODE to enter background mode;</li><li>(2) watch the display start flashing the old background and remember the number;</li><li>(3) when you see a new flashing number, the background has been updated and you <i>must</i></li><li>(4) press MODE again to return to searching.</li></ol> <div data-bbox="773 753 1146 923" style="border: 1px solid black; padding: 5px; text-align: center;"><p><b>With this version, always check to be sure that you are in search mode when you begin a search.</b></p></div>
	<p><i>Inactive Version (VI.01)</i></p> <p>This version has an inactive MODE switch. To update the background, you must</p> <ol style="list-style-type: none"><li>(1) press POWER to turn off the PRM-470A;</li><li>(2) press POWER to turn it back on; and</li><li>(3) wait for the warmup, background measurement countdown and start of operation in search mode.</li></ol>

**Control Panel (continued)**

<b>Component</b>	<b>Operation</b>
<p>COUNTS/SECOND</p>  <p>X 1000</p> <p><b>Count rate display</b></p>	<p>The count rate display is an LCD that shows the PRM-470A detector count rate in counts per second. To read the count rate, multiply the display (0.139) by 1000 to get the result (139) in counts per second.</p> <ul style="list-style-type: none"> <li>• If the number on the display changes each second, the monitor is searching.</li> <li>• If the number counts down or flashes on and off, the monitor is updating the background.</li> <li>• If you see LO instead of a number, it is because the monitor checks its battery voltage and displays the letters "LO," sounds its beeper for 5 seconds and turns itself off when the battery is low.</li> </ul>
 <p><b>Display light</b></p>	<p>At night or in dark places, you can press LIGHT to illuminate the display. LIGHT turns itself off after 30 seconds.</p>
 <p><b>Beeper</b></p>	<p>The beeper sound indicates an alarm in search mode. Occasional beeps are usually from natural variation in count rate. Frequent beeps usually indicate a radiation source. The beeper also sounds after POWER is pressed and when the battery is low.</p>
<p>BATTERY</p>  <p>CHARGER</p> <p><b>Battery charge</b></p>	<p>When the battery is low, it can be recharged. First turn off the monitor. Then attach the charger cable to the monitor and plug the charger into a wall socket.</p>



*If you see "LO" displayed,  
hear a long beep, or find your  
PRM-470A turning itself off, it  
needs to be recharged.*

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## GAMMA RADIATION

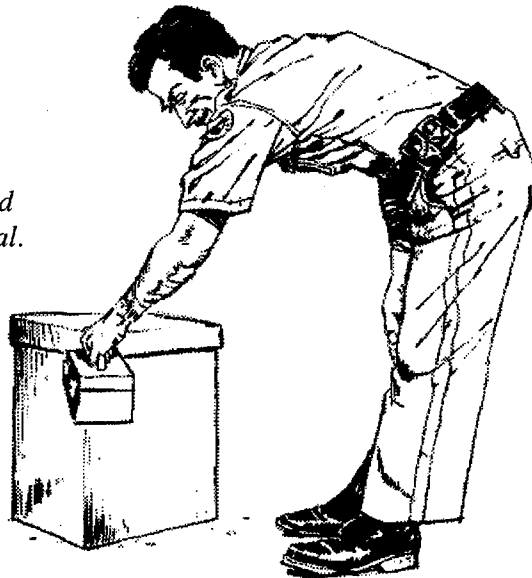
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Gamma radiation is emitted by radioactive atoms that are part of the natural environment. Gamma radiation is similar to light, except that the eye cannot see it. A radiation source emits gamma rays in all directions, just as a light bulb emits light in all directions. And, just as the intensity of light fades rapidly as you move away from a light bulb, the intensity of gamma radiation fades as you move away from its source. This comparison is true for bare light bulbs only; reflectors or lamp shades can redirect visible light, but there is no way to redirect the flow of gamma radiation.

### Radiation Shields

The closer your monitor comes to radioactive material, the greater the radiation intensity and the easier it is to find the material. To find radioactive material, you should follow the direction of increasing intensity, that is, more frequent beeps. However, certain shields in the path of gamma rays block their passage, just as objects in the

*Move in close with  
your monitor to find  
radioactive material.*



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## Gamma Radiation (*continued*)

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path of light create a shadow. Look for shields that may shadow radioactive material and prevent your monitor from detecting it. For example, brick and concrete walls, thick metal containers, and sheets of lead are shields that can reduce radiation intensity.

### Radiation Sources

The natural surroundings and SNM are not the only sources of gamma radiation. Occasionally, you may find radioactivity in everyday items. For example, some people may still wear watches with glow-in-the-dark radium dials that your monitor will sense. Radium-dial watches are intense radiation emitters and a health hazard to the skin of a person who wears the watch for long periods of time. Now most glow-in-the-dark watches have harmless tritium dials that your monitor will not detect because they emit beta radiation, which is totally absorbed inside the watch.

In addition to radioactive watches, some camera lenses are radioactive because they are made with a type of glass that may contain thorium, a natural radioactive element. Another common item that contains thorium, perhaps less likely to be encountered at a search station, is a Coleman® lantern mantle. The mantle, a small net bag, is the part of a gasoline lantern that glows when the lantern is lit. *Only the newest mantles are not radioactive.* Most of the thorium-containing items are low-intensity gamma-ray emitters; you may not be able to detect radiation from an old mantle, for instance, unless your monitor is almost touching it.

A relatively uncommon form of radioactivity that security inspectors encounter once in a great while is inside people who are undergoing diagnosis with a medical radioisotope. When these individuals present themselves for search before their bodies have had time to eliminate the radioisotope, they can be very intense sources of gamma radiation. Normally, these individuals are cleared through a search station by special procedures.



***Contamination***

Another infrequent source of radiation detected at search stations is contamination. Occasionally, a security inspector will detect a person with contaminated protective clothing or equipment. For example, an inspector may detect contamination on someone's coveralls. This can happen when a persistent gamma-ray emitter does not wash out in the laundry. Or the contamination may be fresh. Security inspectors detect gamma-ray contamination because their search monitors are highly sensitive to gamma rays and can detect very small amounts of certain radioactive materials.

***Background radiation***

Finally, a word about the background radiation at a monitoring station. The background may vary occasionally. Perhaps it will be a slight natural variation caused by changes in the weather. Some natural radioactive atoms are part of the atmosphere or are attached to dust that is suspended in the air. When it rains, these particles are washed out of the air onto the ground, and the background radiation level temporarily increases. Other more noticeable changes in background may be caused by temporary operations at a work site, such as movement of radioactive material or operation of a nuclear reactor. In any case, your monitor is so sensitive that it will notice even slight variations in background radiation.

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## **Gamma Radiation (*continued*)**

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### **Summary**

As we have seen, SNM emits radiation that your monitor can detect. You should also keep in mind the other sources of radiation that your monitor will detect. Neutron sources, for example, are rarely encountered, but neutrons from plutonium are important for detecting plutonium when it is shielded. The more common radiation sources that you may encounter on the job are listed below.

#### **Sources of Radiation**

- Natural background
- Low-level contamination
- Radium dial wristwatch
- Camera lens containing thorium
- Medical radioisotope treatment
- Special nuclear material (SNM)

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## OPERATING THE PRM-470A

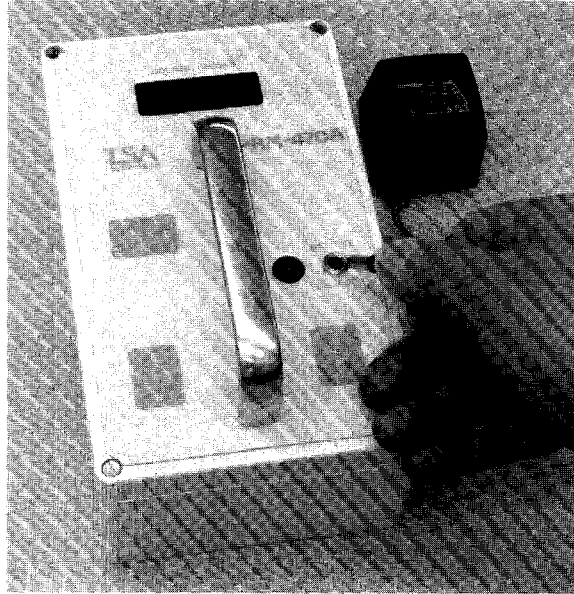
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Operating your monitor properly takes a certain amount of know-how. The following steps ensure proper monitoring when you conduct a search and are further described below.

Step	Action
1	Make sure the battery is charged and the power is turned on.
2	See that the LCD has a steady display of count rates updated each second.
3	To conduct a search, grasp the instrument firmly in one hand so you can read the writing on the front panel; this places the sensitive end of the monitor away from you. Note: Armed inspectors are expected to keep their strong hand free, so the other hand should grasp the PRM-470A.
4	Reset the background if necessary.
5	Always keep the monitor within 4 to 6 inches of the surface you are searching.

### Battery Recharge

The rechargeable battery will operate the monitor for up to 60 hours. When you are not using the monitor for long periods of time, recharge it by attaching the charger to it (see photograph on following page) and plugging the charger into an electrical outlet. However, don't make the habit of continuously charging the monitor because it is unhealthy for the batteries. A second fully charged monitor should be available for use when the first needs to be charged.



### **Turning the Power On**

To operate the monitor, press the POWER switch. The display will show 8's and the beeper will sound, then the current alarm factor\* is displayed during a short warm-up period. Next, the display counts down to zero until the monitor is ready for operation and displaying a new count rate once per second.

### **Setting the Background**

When the power is turned on, the PRM-470A measures the radiation background while it shows a countdown from 9 to 0 on its display. The average count rate is not displayed, but it is stored in the monitor's memory.

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\* The alarm factor can be as large as 4 for plutonium monitoring, but no greater than 3 for uranium monitoring.

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## Operating the PRM-470A (continued)

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The background produces count rates of roughly 130 counts per second in the PRM-470A when it is calibrated using the manufacturer's procedures. The count rate may be higher or lower at your station. A large decrease or increase from count rates that you usually see could indicate that the background has changed for some reason. It could also indicate that your monitor may need repair, so if it persists, tell your supervisor.

There is one obvious way to tell when you need to take a new background: the monitor beeps too often. When the background is properly set, the monitor may beep occasionally. To reset background, use the procedure for your operating program listed under MODE switch in the section on Panel Functions beginning on p. 7.

### Using the Monitor

When the monitor is turned on and has a recent background measurement, it is ready for use. If the monitor is already at the search location, you are ready to conduct a search. If the monitor is inside the station and you take it outside to search, you may have to reset the background. Or, if it has been quite a while since you set the background, you may have to reset it just before starting a search. In either case, reset the background in the search area but not close to the search object. Your best bet is to leave the monitor at the search location to minimize the amount of background resetting.

#### **Background Radiation**

A count rate of 130 (0.130) or so on the PRM-470A display would be normal in the natural background.

#### **Radiation Areas**

Radiation areas where you should not loiter are posted with yellow and magenta warning signs and may have backgrounds of several milliroentgens per hour. In these areas, the PRM-470A might display numbers in the tens of thousands (10.00) if gamma radiation is the reason for posting.

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## SEARCH TECHNIQUES FOR PERSONNEL, PACKAGES, AND MOTOR VEHICLES

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Your sensitive and intelligent monitor is only as good as your search technique. The care and thoroughness that you take in conducting a search are essential to the security of the access area that you are protecting. The recommended search techniques that follow are for locating small quantities of SNM. Large amounts are easy to detect, of course, and require no additional steps.

Careful search techniques involve the following steps. **A detailed search checklist can be found at the end of this document.**

Step	Action
1	Scan the monitor over the surface of every person, package, and vehicle.
2	Avoid contact when monitoring: a distance of 2 to 6 inches from a surface is close enough.
3	Notice that when the monitor senses a source of radiation, it will begin beeping more and more as the monitor approaches the radiation source. Pinpoint small sources of radiation by moving the monitor around a radioactive area to find the strongest response. Note: If the monitor beeps everywhere as you move the monitor around an object, the radioactivity may be distributed uniformly over the object. This sometimes happens in the case of contamination.

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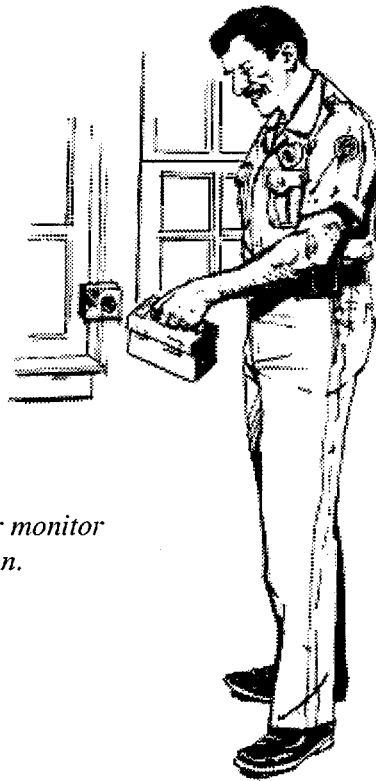
## Search Techniques *(continued)*

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### Daily or Shift-Change Performance Check

Certain checks must be performed regularly to verify that the NNV-470A monitor is operating properly.

Step	Action
1	Turn the monitor on, if necessary.
2	Check that it has a recent background.
3	Bring your monitor near the small radioactive source that is kept in the station for performance check and verify that it detects the radiation.



*Verify that your monitor detects radiation.*

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## Search Techniques *(continued)*

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### Personnel Search

Follow these procedures to perform a thorough personnel search. Allow 15 seconds to conduct it. This is enough time to search the person front and back.

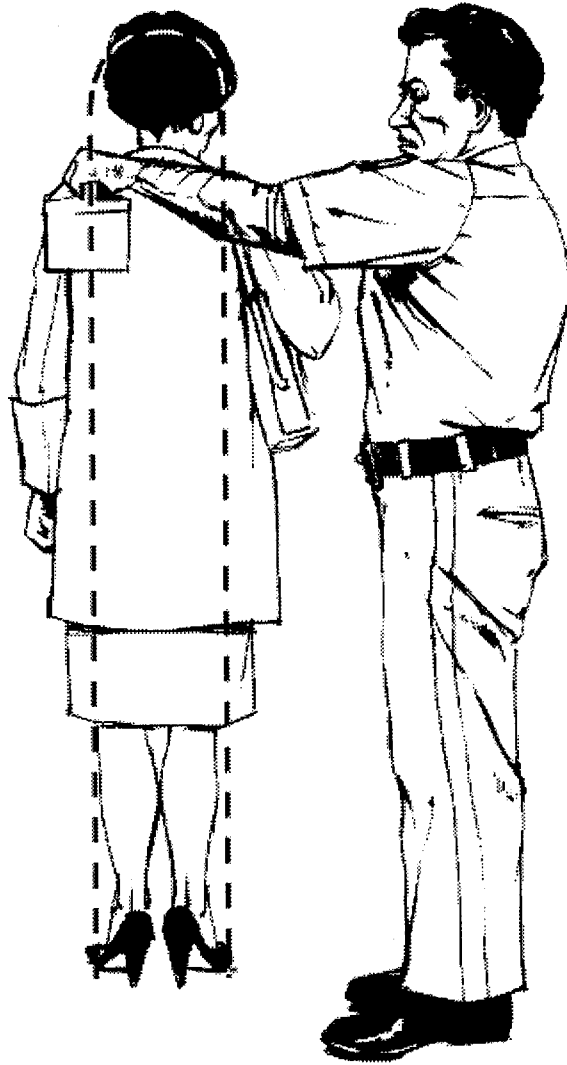
Note: You may move your monitor rapidly, but remember that it will only detect radioactive material if it is close enough to sense it.

Step	Action
1	Begin your scan near one foot. Sweep up one side of the body to the head, then sweep down the other side.
2	Ask the person to turn around and repeat the inverted U-shaped scan.
3	Pace your scan. Each sweep should take 2 or 3 seconds. Hence, a front scan will take 5 or 6 seconds, turning around takes a few more seconds, and a back scan takes 5 or 6 seconds, for a total of 15 seconds.



*Scan personnel with a U-shaped scan.*





*Be sure to scan both front and back.*

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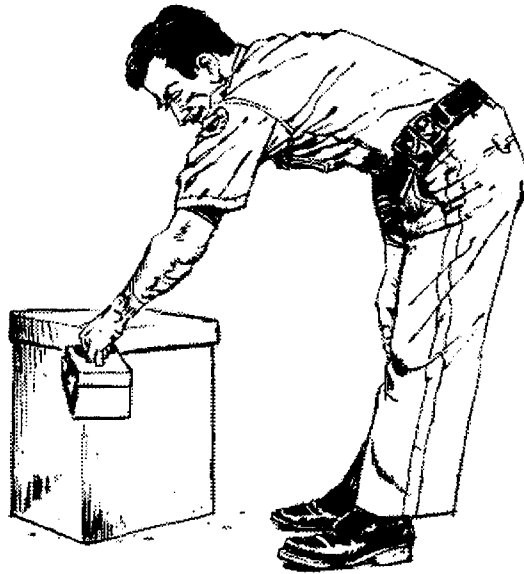
**Search Techniques (continued)**

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**Package Search**

Briefcases, purses, and packages are the common items that people carry; follow these steps to search them.

Step	Action
1	Pass the monitor over the surface of each item.
2	Ask the person to open large items for a visual search.
3	Look for large, heavy objects that may be radiation shields.
4	If a package is sealed and cannot be opened for a visual search, use more care in scanning to make sure it does not contain SNM.
5	Search slowly over the surface of the package, taking plenty of time to scan all sides.



*Exercise care in scanning sealed packages.*

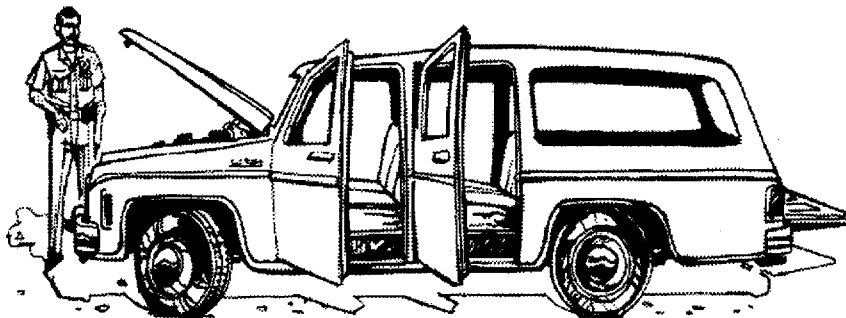
## Motor Vehicle Search

Motor vehicles are more challenging to search for SNM than people or packages. The search is a much longer procedure. Remember to do a visual search as you scan with your monitor. Check large, heavy containers very carefully with your monitor.

### *Preparing for a motor vehicle search*

Certain procedures must be followed before you can even begin to search a motor vehicle. Follow these steps to prepare for the motor vehicle search:

Step	Action
1	Make sure the monitor is turned on, is operating properly, and has a recent background.
2	Prepare the vehicle for search by asking the driver to shut off the engine and open the hood, trunk, and all doors.
3	Request that the driver and any passengers get out of the vehicle and stand away from it during the search.



*Prepare the vehicle for search.*

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## Search Techniques *(continued)*

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### *Searching occupants*

A vehicle search involves not only the vehicle itself but also any occupants of the vehicle. Conduct a personnel search of each occupant while they are out of the vehicle. Allow them to go back inside *after* you complete your vehicle search.

### *Searching the vehicle*

You are now ready to conduct a motor vehicle search. Follow these steps to ensure a thorough vehicle search. Remember to move the monitor within 6 inches of every surface.

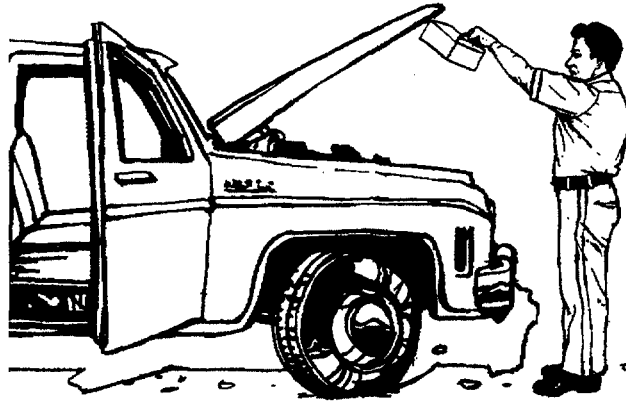
Step	Action
1	Search under the vehicle's hood. Don't forget to search the hood itself.
2	Search the vehicle's trunk.
3	Search the vehicle's interior. <ul style="list-style-type: none"><li>• Enter each door and search around every object and surface within reach.</li><li>• Include unlikely places, such as the dashboard, sun visor, headliner area, floor, under the seats, and the space behind the rear seat.</li></ul> Note: If you cannot reach an area, search it from outside the vehicle, through glass whenever possible instead of through metal. Take extra time when you are searching the inside of a vehicle from outside.
4	Search the cargo areas in trucks.
5	Search the exterior of the vehicle. Include under frame rails and bumpers, and the wheel wells in front and behind the tires.

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**Search Techniques (continued)**

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*Include the hood as well in your search.*

***Searching special vehicles***

In addition to the standard scanning procedures for all vehicles, some vehicles require additional steps in scanning. Follow these additional steps for special vehicles.

<b>Vehicle</b>	<b>Action</b>
Pickup trucks	Scan the bed of the pickup. Just because the bed is empty does not mean you can skip it. A container of SNM may be attached to the underside.
Large trucks (step vans, flatbed trucks, dump trucks, garbage trucks, etc.)	Search wherever possible. It helps to have a small stepladder or step stool to reach the high places. Search all the accessible spaces and search the exterior of any inaccessible spaces.
Escorted commercial vehicles	Search even though they have been watched by a security escort. The escort is responsible for watching the occupants, which may take their eyes off the vehicle; therefore, conduct a full search of the vehicle.

### What To Do When You Find Radioactive Material

Your station orders should tell you specifically what to do when you detect SNM or other radioactive materials.



*Use your eyes as well as your ears in searching.*

**SEARCH CHECKLIST**

**Note: Search distance is 2 to 6 inches from surface.**

**Preliminaries**

- Monitor is turned on
- Background is current

**Personnel Search (15 seconds)**

- Front (inverted U-shaped scan)
- Back (inverted U-shaped scan)

**Package Search**

- Monitor inside and conduct a visual inspection
- Monitor outside very carefully for sealed packages

**Motor Vehicle Search**

- Engine shut off
- Driver and passengers get out and open compartments
- Search occupants
- Search engine area under hood
- Search hood
- Search trunk area
- Search trunk lid
- Search under seats
- Search dashboard
- Search sun visor
- Search headliner
- Search floor
- Search behind rear seat
- Search cargo area of trucks
- Search under frame rails
- Search under bumpers
- Search wheel wells
- Search bed of pickup trucks

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# Los Alamos

NATIONAL LABORATORY

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