Nuclear Radiation FAQ

Compiled by Zulu Cowboy

Q: What's the Difference Between Alpha, Beta and Gamma Radiation?

A: Everything in nature would prefer to be in a relaxed or stable state. Unstable atoms undergo nuclear processes that cause them to become more stable. One such process involves emitting excess energy from the nucleus. This process is called radioactivity or radioactive decay. "Radiation" and "radioactivity" are often confused, the proper relationship is that "radioactive atoms emit radiation."

The three main types of nuclear radiation emitted from radioactive atoms are:

Alpha: These are actual particles that are electrically charged and are commonly referred to as alpha particles. Alpha particles are the least penetrating of the three primary forms of radiation, as they cannot travel more than four to seven inches in air and a single sheet of paper or the outermost layer of dead skin that covers the body will stop them. However, if alpha particle emitting radioactive material is inhaled or ingested, they can be a very damaging source of radiation with their short range being concentrated internally in a very localized area.

Beta: These are also actual particles that are electrically charged and are commonly referred to as beta particles. Beta particles travel faster and penetrate further than alpha particles. They can travel from a few millimeters up to about ten yards in open air depending on the particular isotope and they can penetrate several millimeters through tissue. Beta particle radiation is generally a slight external exposure hazard, although prolonged exposure to large amounts can cause skin burns and it is also a major hazard when interacting with the lens of the eye. However, like alpha particles, the greatest threat is if beta particle emitting radioactive material is inhaled or ingested as it can also do grave internal damage.

Gamma: Gamma rays are similar to x-rays, they are a form of electromagnetic radiation. Gamma rays are the most hazardous type of external radiation as they can travel up to a mile in open air and penetrate all types of materials. Since gamma rays penetrate more deeply through the body than alpha or beta particles, all tissues and organs can be damaged by sources from outside of the body. Only sufficiently dense shielding and/or distance from gamma ray emitting radioactive material can provide protection.

Bottom Line: All three of the primary types of radiation above can be a hazard if emitted from radioactive material that was inhaled or ingested. Protected food and water and even a simple inexpensive dust protector face mask can go a long ways to denying this route of entry. However, for the penetrating gamma rays, it is essential to be able to measure the strength of this type of radiation to then discover the best protected shielding and distance options available. Also, in a shelter or home, besides revealing the safest locations there, knowing the intensity of the local gamma radiation outside will better indicate when it is again safe. Or, safe enough to perform a brief essential chore outside.

Q: What's the Difference Between Roentgen, Rad and Rem Radiation Measurements?

A: Since nuclear radiation affects people, we must be able to measure its presence. We also need to relate the amount of radiation received by the body to its physiological effects. Two terms used to relate the amount of radiation received by the body are exposure and dose. When you are exposed to radiation, your body absorbs a dose of radiation.

As in most measurement quantities, certain units are used to properly express the measurement. For radiation measurements they are...

Roentgen: The roentgen measures the energy produced by gamma radiation in a cubic centimeter of air. It is usually abbreviated with the capital letter "R". A milliroentgen, or "mR", is equal to one one-thousandth of a roentgen. An exposure of 50 roentgens would be written "50 R".

Rad: Or, Radiation Absorbed Dose recognizes that different materials that receive the same exposure may not absorb the same amount of energy. A rad measures the amount of radiation energy transferred to some mass of material, typically humans. One roentgen of gamma radiation exposure results in about one rad of absorbed dose.

Rem: Or, Roentgen Equivalent Man is a unit that relates the dose of any radiation to the biological effect of that dose. To relate the absorbed dose of specific types of radiation to their biological effect, a "quality factor" must be multiplied by the dose in rad, which then shows the dose in rems. For gamma rays and beta particles, 1 rad of exposure results in 1 rem of dose. Other measurement terms: Standard International (SI) units which may be used in place of the rem and the rad are the sievert (Sv) and the gray (Gy). These units are related as follows: 1Sv = 100 rem, 1Gy = 100 rad. Two other terms which refer to the rate of radioactive decay of a radioactive material are curie (Ci) and becquerel (Bq).

Bottom Line: Fortunately, cutting through the above confusion, for purposes of practical radiation protection in humans, most experts agree (including FEMA Emergency Management Institute) that Roentgen, Rad and Rem can all be considered equivalent. The exposure rates you'll usually see will be expressed simply in terms of roentgen (R) or milliroentgen (mR).

Q: What's the Difference Between Survey Meters, Geiger Counters and Dosimeters?

A: **Survey meters**, field survey meters, rate meters, radioactivity meters, radiation detection meters, low-range meters, high-range meters, airborne meters, fallout meters, remote monitors, Geiger counters, and even 'dose rate meters' are all describing instruments that measure exposure rate or the intensity of radiation at a location at some point in time. It's like the speedometer of a car; both present measurements relative to time. All of these above 'meters', the Geiger counter, too (which utilizes a Geiger tube rather than an ion chamber), will show their radiation intensity readings relative to time, such as R/hr or mR/hr like the scale at the right, same as a car speedometer will show miles/hr. If you entered a radioactive area and your meter says 60 R/hr then that means if you were to stay there for a whole hour you would be exposed to 60 R. Same as driving a car for an hour at 60 mph, you'd be 60 miles down the road after that hour, at that rate.

Dosimeters, which are also available in high or low ranges, can be in the form of a badge, pen/tube type, or even a digital readout and all measure exposure or the total accumulated amount of radiation to which you were exposed. (The Civil Defense pen/tube tube would show a reading like at the right when looking through it.) It's also similar to the odometer of a car; where both measure an accumulation of units. The dosimeter will indicate a certain total number of R or mR exposure received, just as the car odometer will register a certain number of miles traveled.

Example of the relationship between a survey meter and a dosimeter;
If you had a survey meter in one hand and a dosimeter in the other and walked into an area of measurable radiation and your survey meter said you were now standing in a 30 R/hr radiation field, and you stayed there for two hours, then your dosimeter at the end of those two hours would be indicating 60 R. The meter measured the exposure rate or intensity of the radiation there and the dosimeter accumulated the total amount of radiation you had been exposed to for having been there those two hours. (If you had left right after the first half-hour, then your dosimeter would have been reading only 15 R.)

Bottom Line: Both meters and dosimeters have their place, and their limitations, in indicating the presence of hazardous radiation levels, and when utilized by a person with the basic understanding of what they are each measuring, they can be critical life-saving tools to survival in a nuclear emergency.

Note: It should be readily apparent now that the more dangerous levels of radiation are well beyond the capability of a low-range survey meter, such as the CD V-700, which would be maxed out at 50 mR/hr which is only .05 R/hr. (A low-range meter is better suited for verifying successful decontamination and/or checking for low-level contamination in food or water.) With that meter alone, and maxed out, you would not know if you just walked into a 1 R/hr or a potentially fatal 1000+ R/hr environment.

Instruments that measure only milliroentgen-range dose rates are sold for war use by some companies. Since most Americans have no idea what size of radiation doses would incapacitate or kill them, and do not even know that a milliroentgen is 1/1000 of a roentgen, some people buy instruments that are capable of measuring maximum dose rates of only one roentgen or less per hour. The highest dose rate that it can measure, one roentgen per hour is far too low to be of much use in a nuclear war.

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The Biological Effects of Radiation

Biological effect begins with the ionization of atoms. The mechanism by which radiation causes damage to human tissue, or any other material, is by ionization of atoms in the material. Ionizing radiation absorbed by human tissue has enough energy to remove electrons from the atoms that make up molecules of the tissue. When the electron that was shared by the two atoms to form a molecular bond is dislodged by ionizing radiation, the bond is broken and thus, the molecule falls apart. This is a basic model for understanding radiation damage. When ionizing radiation interacts with cells, it may or may not strike a critical part of the cell. We consider the chromosomes to be the most critical part of the cell since they contain the genetic information and instructions required for the cell to perform its function and to make copies of itself for reproduction purposes. Also, there are very effective repair mechanisms at work constantly which repair cellular damage - including chromosome damage.

ACUTE AND CHRONIC RADIATION DOSE

Potential biological effects depend on how much and how fast a radiation dose is received. Radiation doses can be grouped into two categories, acute and chronic dose.

Acute dose

An acute radiation dose is defined as a large dose (10 rad or greater, to the whole body) delivered during a short period of time (on the order of a few days at the most). If large enough, it may result in effects, which are observable within a period of hours to weeks.

Acute doses can cause a pattern of clearly identifiable symptoms (syndromes). These conditions are referred to in general as Acute Radiation Syndrome. Radiation sickness symptoms are apparent following acute doses >100 rad. Acute whole body doses of >450 rad may result in a statistical expectation that 50% of the population exposed will die within 60 days without medical attention.

As in most illnesses, the specific symptoms, the therapy that a doctor might prescribe, and the prospects for recovery vary from one person to another and are generally dependent on the age and general health of the individual.

Blood-forming organ (Bone marrow) syndrome (>100 rad) is characterized by damage to cells that divide at the most rapid pace (such as bone marrow, the spleen and lymphatic tissue). Symptoms include internal bleeding, fatigue, bacterial infections, and fever.

Gastrointestinal tract syndrome (>1000 rad) is characterized by damage to cells that divide less rapidly (such as the linings of the stomach and intestines). Symptoms include nausea, vomiting, diarrhea, dehydration, electrolytic imbalance, loss of digestion ability, bleeding ulcers, and the symptoms of blood-forming organ syndrome.

Central nervous system syndrome (>5000 rad) is characterized by damage to cells that do not reproduce such as nerve cells. Symptoms include loss of coordination, confusion, coma, convulsions, shock, and the symptoms of the blood forming organ and gastrointestinal tract syndromes. Scientists now have evidence that death under these conditions is not caused by actual radiation damage to the nervous system, but rather from complications caused by internal bleeding, and fluid and pressure build-up on the brain.

Other effects from an acute radiation dose include:

200 to 300 rad to the skin can result in the reddening of the skin (erythema), similar to a mild sunburn and may result in hair loss due to damage to hair follicles.

125 to 200 rad to the ovaries can result in prolonged or permanent suppression of menstruation in about fifty percent (50%) of women.

600 rad to the ovaries or testicles can result in *permanent sterilization.*

50 rad to the thyroid gland can result in benign (non-cancerous) tumors.

As a group, the effects caused by acute doses are called deterministic. Broadly speaking, this means that severity of the effect is determined by the amount of dose received. Deterministic effects usually have some threshold level - below which, the effect will probably not occur, but above which the effect is expected. When the dose is above the threshold, the severity of the effect increases as the dose increases.

Chronic dose

A chronic dose is a relatively small amount of radiation received over a long period of time. The body is better equipped to tolerate a chronic dose than an acute dose. The body has time to repair damage because a smaller percentage of the cells need repair at any given time. The body also has time to replace dead or non-functioning cells with new, healthy cells. This is the type of dose received as occupational exposure.

The biological effects of high levels of radiation exposure are fairly well known, but the effects of low levels of radiation are more difficult to determine because the deterministic effects described above do not occur at these levels.

Since deterministic effects do not generally occur with chronic dose, in order to assess the risk of this exposure, we must look to other types of effects. Studies of people who have received high doses have shown a link between radiation dose and some delayed or latent effects. These effects include some forms of cancer and genetic effects.

SOMATIC VS GENETIC EFFECTS

Somatic effects appear in the exposed person. Somatic effects may be divided into two classes based on the rate at which the dose was received.

Prompt Somatic Effects are those that occur soon after an acute dose (typically 10 rad or greater to the whole body in a short period of time). One example of a prompt effect is the temporary hair loss, which occurs about three weeks after a dose of 400 rad to the scalp. New hair is expected to grow within two months after the dose, although the color and texture may be different.

Delayed Somatic Effects are those that may occur years after radiation doses are received. Among the delayed effects thus far observed have been an increased potential for the development of cancer and cataracts. Since some forms of cancer are among the most probable delayed effects, the established dose limits were formulated with this risk in mind. These limits are set such that the calculated risk of cancer in radiation workers is an increase of a very small fraction of the normal cancer risk. (More on risk in a moment).

Genetic or Heritable Effects appear in the future generations of the exposed persons as a result of radiation damage to the reproductive cells. Genetic effects are abnormalities that may occur in the future generations of exposed individuals. They have been extensively studied in plants and animals, but risks for genetic effects in humans are seen to be considerably smaller than the risks for somatic effects. Therefore, the limits used to protect the exposed person from harm are equally effective to protect future generations from harm.

PRENATAL RADIATION EXPOSURE

Since an embryo/fetus is especially sensitive to radiation, (embryo/fetus cells are rapidly dividing) special considerations are given to pregnant workers. Protection of the embryo/fetus is important because the embryo/fetus is considered to be at the most radiosensitive stage of human development, particularly in the first 20 weeks of pregnancy.

Limits are established to protect the embryo/fetus from any potential effects, which may occur from a significant amount of radiation. This radiation exposure may be the result of exposure to external sources of radiation or internal sources of radioactive material.

Potential effects associated with prenatal radiation doses include:

Growth retardation

Small head/brain size

Mental retardation

Childhood cancer

Radiation Dose VS the Effects on Health

The following is interpreted from attached "official" and other "expert" sources. These sources often provide a 'range' for effects, but I have simplified this to a single number to make the table easier to memorize - ***and you should memorize it***. You can then 'extrapolate' for yourself the relative severity of effects of a number between a higher and lower number.

600R -- means 100% chance of fatality is expected.
Some much earlier - but the last within two weeks.

400R -- means 50% will die within one to three weeks.
Those that don't die are going to be VERY sick and wish they were dead. After a few days some may feel better but will often then turn, sicken and die within a few weeks.

200R -- lots of sickness, and radiation sickness is pretty terrible (Think cancer treatments without the pain killers.)
Lots of vomiting - hair falling out - and all that…
Not very pleasant.

50R -- No fatalities at this level. There is a difference of opinion, as to whether the sickness at this level is physical. Some think, as for example in this very authoritative study, that at this level the sickness is psychosomatic. Whatever its cause it is very general.

30R -- Most everyone will feel some sickness - Maybe just "punky" and it may be "just" psychosomatic but it certainly would not be beneficial for children and pregnant mothers. Even this level is a thousand times higher than the maximum general population exposure permitted under peacetime standards.

In the final analysis, fatality is probabilistic, somewhat like car accident fatalities. There have been cases of people getting a lot higher dose of radiation and surviving, verses others exposed to much lower levels, who have perished. Cause and effect become clouded when working with probabilities. There are many impinging factors, such as age, health, medical care, or the lack thereof.

You Will Survive Doomsday

By Bruce Beach

http://www.radmeters4u.com/survival/books/doomsday/index.htm

Our purpose in publishing this document is to ameliorate the effects of a nuclear holocaust for as many people as we can reach, and to locate as many people as we can who are willing and able to join our nuclear survival group.

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Here are twenty-three myths that are repeatedly heard (some much more often than others) that this document tries to dispel.

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- MYTH #20: The bombs today are so large and there are so many they will destroy the world.
- MYTH #21: You will receive adequate warning from your government.

This document is published by a nuclear survival group. The group is not affiliated with any religious group or other organization. We welcome inquiries from all persons interested in joining our survival group. Send email to survival@webpal.org (*Bruce Beach*) for more details.

DOOMSDAY

MYTH #01: Almost everyone will suddenly be killed on doomsday. Return to index

You will survive doomsday. And here you thought that if it ever happened the bomb would fall right on you. Probably not. It will more likely go like this.

One day, the inferior Russian computers may make a mistake and decide that the US has already launched a pre-emptory attack against Russia. The US warning system has made that same sort of mistake many times and a number of times we have gotten just minutes away from launching our retaliation before the mistake was discovered. Who is to say the Russians will always be so smart?

Forty minutes after a missile is launched from Russia it will be landing on its target in North America. Before this occurs the US has just minutes within which to respond or it will be caught with its missiles down. The hotline to Russia happens to be not working (this has also happened a number of times before). That is one of the factors that entered into the Russians decision to launch.

So, what's his name in the White House reaches for a jellybean and pushes the button.

Interception missiles of course try to stop the Russian missiles before they reach their first two primary targets, NORAD (NORthern Air Defense) headquarters in Colorado Springs, Colorado and its backup at North Bay, Ontario.

These are hardened underground computer and communication sites that may require several bombs to wipe them out. Given the number of missiles that may be intercepted the Russians have sent a handful.

A better way to wipe out the communications of North America is to just explode four thermonuclear devices at a high altitude over the continent. These will generate an EMP (Electro Magnetic Pulse) that will knock out most electric and electronic devices tied into the power grids. It will also knock out any new devices that contain IC's (integrated circuits) and that have an antenna over thirty inches long. That means that your car radio, portable radio, and television will be inoperable, even if the power ever does come back on.

All over the continent the power and lights will suddenly go off. If you happen to be listening to a battery operated old tube type radio (when did you last see one of those?) that is tuned into a "hardened" transmitter sight (I don't know where you will find one) that transmits (fat chance) the EBS (Emergency Broadcast Signal) then you will know that doomsday has begun.

Otherwise you will be standing out there with the rest of us survivors saying, "Nice day, eh? Strange the power would go off on a nice day like this." Silence. The sun will continue to shine, and the birds will sing, and the breezes will blow and you will still not know that they have a bit of a problem up in North Bay. They are no longer there. Silence.

Eventually word may drift in. On the chance that there is something to the rumor you decide to try to call someone. Your spouse, a friend, a relative. Don't bother. Silence. The telephone isn't working either. Even if the EMP hadn't done it in, a mere power outage causes such an overload of demand on the central exchange that you couldn't even get a dial tone.

You are a survivor. Doomsday has occurred and you are a survivor. While you are waiting for the spouse and kids to get home maybe you should do something practical. Like go down to the supermarket and lay in a bit of an extra stock.

You may notice that the little corner store has closed. If he has believed the rumor, he wants to save his stock. And besides, your money may not be worth anything tomorrow. You thought you had seen rapid inflation before but this is like from zero to a million in sixty seconds.
At the supermarket, if you are early enough, you will find pandemonium. If not, you will find practically nothing. Maybe a large bag of dog food (take it) and some cans of floor wax (forget it). The rest of the stuff was all in those carts that you met come flying up the walk as you came running down.
There won't be any girls at the cash registers, (they have done their shopping and gone). Besides, the cash registers aren't working anyhow, with no power. It may have taken the hired manager a little longer to figure out that he should grab what he can and head home to his family, but he has probably gone now. The only cops you will see are the one's grabbing stuff themselves.
If on the way back you spot a shopping basket with something in it - think twice before helping yourself. If there is an altercation there are probably no doctors at the hospital to sew up the lacerations. Everyone else is also too busy to bother calling an ambulance, if they could, and one wouldn't be available if they did.
Of course the trip to the supermarket may have been nothing like that at all. It may have just been a bit more active than usual but if most people haven't caught on yet then we are very lucky. You just keep mumbling under your breath. "Good people, good people - that's the way, that's the way, just stay calm." This way we can just go about doing what we have to do as quickly as we can, while trying to not stir up panic. "Yes. I understand the cash registers aren't working but please let me just help you add this up by hand. No, that's fine, just keep the change."
Then, of course, if everything is really this calm we can take that good old plastic credit card and go out and buy all the good survival stuff that we are going to need and should have gotten beforehand. Don't worry about paying for it, no one is ever going to send you a bill. Getting the stuff home may be a bit of a problem if the car isn't working (the EMP may have wiped out that fancy electronic ignition). "No, that's fine. You don't need to deliver it. I'll just put it here in my little red wagon." But you sure don't want to lug it all the way up to your thirty-second floor apartment, if there is somewhere safe that you can stash it. "Can you really believe that people are staying this calm? How is it that we seem to be so much smarter than the rest?"
More than likely you are now back home and all you have is the fifty-pound bag of dog food. Are you really going to be able to carry it up to your thirty-second floor apartment? You know the elevators aren't working of course. Then maybe you could hide it in the trunk of your car in the garage- if no one sees you.
Ah, back home in the apartment. Home sweet home. The kids are home from school now. Do you have enough guts after that scene at the supermarket to send them out to do some more scavenging? It isn't exactly a party going on out there. Did you see Watts, Detroit, Washington D.C., and Baltimore after some of their similar parties? I did. I think I would keep the kids home. Not much you can do except to wait for the spouse to walk home. Shouldn't be more than a few hours.
The spouse finally makes it home. "What do you mean all you got is fifty pounds of dog food? We don't even have a dog." The electricity isn't on. We can't cook anything anyway. Best to eat everything out of the refrigerator before it spoils. Won't be anymore water as soon as the gravity feed tanks on the roof empty. Hope you saved a few pot's full. If everyone filled up their bathtubs - it is all gone. It has gotten cold. Might as well go to bed. There is no light to see anything by anyway. Certainly not going out in those streets in this dark with all that noise going on down there. Hopefully, everything will look brighter in the morning.

Day Two

Morning comes early with the noise of people throwing pots and pans over the sides of their balconies along with the blankets, pillows and other things that it saves them carrying down. Apparently some of the residents are moving out. Perhaps you should too.

Everything looks better in the light, doesn't it? TV still doesn't come on. Telephone isn't working either. And you know what - the toilet doesn't flush. Can't cook anything. Got to eat what you've got. See, that wasn't so bad. Make it sort of a picnic. Eat it right out of the can. There is not going to be any water to wash dishes.

But see, **we survived doomsday**. Didn't even see an explosion, hear a bomb, or anything. Maybe we should sit down together and try to figure out what we are going to do from here. The bombs may still be coming. Probably are.

If the attacker's plans have gone according to schedule they have probably finished with their primary targets. They have hit the three Titan Wings in Kansas, Missouri and Arkansas (three wings, eighteen missiles each, for a total or fifty-four) or the things have landed in Russia by now, so why bother. They have certainly been knocking the bejammers out of Montana and the Dakotas. Can't hear or see a thing from here of course. [Author's update note: This is point is a little dated. The Titan Wings have been decommissioned and both the U.S. and Russia have now put much greater reliance upon the MUCH greater and more reliable destructive power of MIRVed warheads aboard nuclear submarines. The primary targets are now most like submarine bases, to prevent more subs from leaving port).

Then they will start on the secondary targets. All the SAC (Strategic Air Command) bases both in the US and around the rest of the world. Oh, they have lots to keep them busy for a while. Cities themselves are pretty far down the list. Maybe they won't even go for them. Any airport with over a ten thousand foot runway is pretty important however because the SAC could land and refuel their bomber there. So you know where that puts us. They will probably get around to us in the next day or two.

There are two strategies of warfare. One is called *counterforce* and the other is called *countervalue*. With counterforce you knockout the enemy's forces so he can't harm you. This can be very chivalrous like the fighting codes of the knights of old. You never harm the women and children.

On the other hand, with countervalue, you go after everything the enemy holds dear in order to demoralize him. This was the technique of the Mongolian hordes.

"Take no prisoners." "Eliminate the enemy." "The only good Indian is a dead Indian." "Eliminate the Jews." "Sock it to the Japs."

Women, children, babies, everybody goes.

Now the problem with countervalue warfare is if everybody knows they are either going to win or die, some people can get very tough. So maybe the best thing is to knockout the military forces and hold the cities as hostage. "Now, either surrender or we bomb the cities." Anyway, the cities aren't generally the first targets.

And so here we sit. **Unscratched**, the day after doomsday. But we can see some problems on the horizon. Very possibly the city is going to be bombed in the next day or two. Even if it isn't, how can we stay here? The electricity is off. The heat is off. The water is off. And it isn't coming back on. The elevators aren't working. For older people it is "If we go down (if they can go down), we can't come back up."

There is no more food in the grocery store. And there won't be any more. (Unless you believe your government, which says they will start delivering it in about two weeks - want to bet?). Then there is that horrible stuff called fallout that is going to start showing up in about twenty-four to forty-eight hours, or sooner.

Now, we have all seen or heard about the book and the movie "On The Beach", and Beach himself shows up with the *solution*. A pocket full of cyanide pills. If you want one he will give you one for each of your kids or grandkids. There is only one catch. There are only so many and I don't want them wasted. So you will have to line up each of your children or grandchildren in a row and pop it down their throats right while I am here. How many of you will do it? "Here is your vitamin. Open wide..."

No? Then you really are a survivor. Here you always said you hoped the bomb would fall right on you and then when I offered you an easy out... Oh well, it won't be that bad. A world without electricity, automobiles, radio, television, telephones, and supermarkets. And maybe eventually with only twenty million people in North America. (They won't all be Canadians).

But then, that is the kind of world that was here in 1800. The people then didn't have cars, supermarkets, movies, TV, radio, telephones, modern medicine, airplanes, rockets, and computers. And they survived. They may have even enjoyed life. Maybe even more than many people do today with all their drugs, tranquilizers, and what have you.

People generally are survivors. Put them out on an ice floe in the middle of the arctic with no expectation of rescue, no supplies - nothing - and they will hold on. Some will even survive until they happen to be rescued.

So you are a survivor and you survived doomsday. But you will eventually die. We will all eventually die. That is the nature of this world. The question is not whether or not you will possibly die, but how long you will live, and what life will be like during that time.

So you have survived. And if you and your kids are going to continue to survive you had better get the heck out of the city. Not only is there the possibility that there will be bombs but those little scenes down at the supermarket, or anywhere else a little bit of food happens to show up, are going to become more and more unpleasant as anarchy prevails.

Moreover, without the toilets flushing and with no one removing the dead bodies, health conditions are really going to reach a state you just wouldn't want me to describe. So, off to the country. But, how? And, where?

Before actually departing for the country let us further consider the alternative of staying in the city. Perhaps you are convinced that the Russians would never really get around to bombing your city. Or you feel you have sufficient underground shelter if they do. Nothing, of course, would protect you if there were a direct hit on your shelter, but a good bomb shelter could certainly give you very good protection as little as five miles from ground zero.

The trouble is that subways and underground garages are not designed as blast shelters. They do not have blast vents and doors. Anyone in such a place, at the time of blast, within a couple of miles of ground zero will be subjected to a phenomenon called *popcorning*. Minute particles of greatly accelerated sand will cause blisters to pop out all over exposed parts of the body. This, combined with several other pathological mechanisms, will probably result in a rather painful death within a few days.

Although the blast protection in an underground shelter is much superior to being above ground there are reasons that one is better off staying in their high-rise apartment rather than going to a large public shelter if they feel there is little or no danger of blast.

The public shelters have no supplies and no equipment. The average designated public shelter is supposed to shelter over three thousand people. Can you imagine the anarchy and conditions there? Without food, the first to die will be infants who are not being breast fed. Other early candidates will be persons who require special medications (especially the elderly) and anyone who happens to be injured.

Not only will deaths have negative psychological effects on the survivors, they will create severe sanitation problems. There will be enough sanitation problems anyway if the water and sewage systems are not working. Most of the designated shelter locations do not have sanitary provision for three thousand people in the first place.

One of the greatest hazards in an underground shelter is carbon dioxide poisoning. The designated public shelters, almost without exception, do not have adequate ventilation for large numbers of people over a considerable period of time. And the existing ventilation systems generally depend upon electricity being available.

There are ventilation defense and survival techniques available. However, if you were to try to implement them in a large public shelter situation you would probably be one of the first persons killed by the other survivors. The reason is that most people have misconceptions about either the air becoming radioactive, or containing radioactive particles that they feel would be more dangerous than the carbon dioxide.

Add to these problems the fact that you might not have any light in the shelter, that anarchy may become rampant, and that there will almost certainly be no food, and perhaps, more importantly, no water and you will see why no trained survivalist would want to be caught dead in the place.

Returning to one's own high rise apartment, after the danger of blast is past, gives much more favorable opportunities for continued survival than given by remaining in a public shelter. If you are ten or fifteen stories above the ground the distance will probably adequately protect you from any radiation from the fallout on the ground. If there are ten or more stories above your head then that distance will also protect you from fallout on the roof.

The apartment dweller should try to secure an inner room without any windows. A blast fifteen or more miles away will knock out the windows and it is the glass shards that will kill most people. Pulling drapes and blinds are all helpful defenses. A blast wave will be preceded by a brilliant flash of light. The survivor will have from several seconds to three or four minutes, depending upon the distance from the blast, to duck behind a sofa or to take other shelter.

Training oneself to take similar immediate defensive action can also help give protection from the intense thermal radiation that accompanies a nuclear blast, and that can start fires *fifteen to twenty* miles from ground zero. Fires, in themselves, can be a problem and if you are downwind from a large fire or firestorm you have to watch out for carbon monoxide poisoning.

Fire defense techniques are generally well known so I will not dwell upon them here. One thing you need not do is call the fire department, if you could. There is little they could do, if they were still around, without central water supplies. But the thing you can do is improvise closings to seal off all the apartments above you, and those immediately below you, so that fallout will not blow in and settle on the floors over your head, or otherwise near you.

Now, it may be possible to organize your activities with other survivors to become a cliff dweller like those of old. A bucket on a rope might be used to haul up water gotten from a nearby stream or pond, and waste could be let down in the same way.

Some ingenuity may be required in providing heat and light, but if you really have sufficient supplies of food for yourself and your fellow survivors to hold out until another crop can be planted and harvested (most survivalists recommend at least two years supply), and you seriously face up to the sanitation problems created by morbidity, and you and your co-survivors are sufficiently organized against anarchy, and there are no more nearer bomb blasts - then you are probably well on your way towards continued survival. At least you are many times better off than being in a public shelter.

There may be all sorts of reasons why you elect to remain in the city rather than head for the country. If the attack comes in the winter and you do not have a planned escape route, adequate clothing and supplies to make the trip, are not physically able to make the trip, and do not have a known destination of refuge, well then...

Those who have most prepared themselves and have made the best plans should pray that their flight does not come in the winter. During a storm, or severely cold weather, it is very likely that many more persons may be killed by exposure than by any other single cause. The roads and highways will most likely be jammed. If there has been an explosion in the vicinity then overpasses and utility lines may have been dropped onto the roadways making them unusable. Even without a blast having occurred, traffic jams, accidents, or vehicles just running out of gas will probably create bottlenecks that completely clog the roads. Once people find themselves just sitting there, not moving, they will abandon their vehicles. My guess is you can forget using an automobile for escape unless you had a plan and immediately implemented it before the general panic set in.

A motorcycle, scooter, or even a bicycle might offer certain advantages over an automobile. One might carry a smaller form of conveyance on a larger one and then implement the smaller means of conveyance, such as a bicycle, when that became the necessity.

The most dependable means of escape would probably remain walking. If one had to walk all the way out, and they were in any physical shape at all, they could surely do it in two or three days. Once again, proper preparation can make all the difference. Proper walking gear, proper survival clothing, a planned escape route, proper selection of material to be packed, and proper allocation of loads.

And, as before, there are better alternatives. One could have pre-arranged pickup points and times with co-survivors coming from the refuge destination, or in a worsening pre-crisis situation you may have made an early dispersal. But the greater likelihood is that anyone with a practical survival plan who reacts immediately can get out well before the rush sets in.

Just getting out into the country, or to the other side of the mountain, will increase the survivability factors for many people. The threats of blast and thermal radiation will have been greatly reduced. But blast and thermal radiation while very nasty in their effects are not going to kill that many people anyway. Oh, they will kill millions, but as a percentage of the people living the day before doomsday they will, combined, kill only ten to fifteen percent. And most of these will be a considerable distance from the blast and will eventually die as a result of injuries caused by the broken glass shards.

As stated before, depending upon the time of year and the weather, many more may be killed by exposure. But there is still another big killer coming. That is of course the fallout from the weapon explosions that took place many hundreds of miles away. This fallout may require from a few hours to a day or two to arrive. If the weather permits, and the survivors know what they are doing, they may still have time to build an expedient shelter against the fallout.

Techniques for defense against fallout have been developed and tested at great expense by almost every nuclear nation. While information on these techniques has been made readily available, most people have not availed themselves of it.

Two basic techniques are available. One is to leave the contaminated area. But the extent of the contaminated area may be far too wide to escape, or one may not have accurate information as to the delineation of the contaminated area, or they may not have the means of transportation, nor the means of survival should they reach a radiation free area.

The other basic means is to provide shelter within the contaminated area. Weather, ground, and time conditions permitting it is possible to dig a trench and cover it with dirt supported by poles, wooden doors, or a vehicle. Properly designed, such an expedient shelter can make all the difference between avoiding the effects of fallout radiation, and not avoiding those effects.

The details of how to build an expedient shelter are to be found in books listed in the bibliography. One of the most important and often overlooked factors in designing a shelter is the matter of providing an airpump so as to eliminate the problem of carbon dioxide poisoning. The technique for building such an expedient pump from materials readily available in time of crisis is also found there.

The effect of fallout radiation is not always death, although many times it is. Even if it is death it is not immediate death. Intense radiation causes a very painful, and horrible death (what the literature calls a *hard* death) over several days. More likely the effects are drawn out over a period of weeks, months, or even years. As the title of this document points out, all these people will have survived doomsday. It is not a question of survival but the condition of survival with which we must concern ourselves. Everyone will die eventually but it is the quality of life in the interim that is of importance.

MYTH #02 Most people would be quickly killed by the bomb blasts, thermal radiation, or radioactivity. Return to index

By the second year after doomsday the combined affects of blast, thermal radiation, and fallout will probably have resulted in some immediate, but mostly delayed, deaths accumulating to 35% of the population that were living on doomsday. Deaths that can be directly attributed to radiation and weapon related injuries will continue until five years after doomsday so that by that time 40% of the population that was living on doomsday may no longer be surviving because of the above named factors.

However, the total population surviving five years after doomsday will probably be only 20% of the number that was living on doomsday) Obviously, nearly half, or perhaps more than half, of the fatalities will be directly contributable to causes other than the bombs.

What then are these equally effective causes of post doomsday mortality? They are exposure, starvation, plagues, and anarchy. While the threat of chemical and biological warfare is not to be ignored the primary causes of these means of mortality can be looked upon as being more *natural*. That is to say they will just result naturally from the breakdown of the social infrastructure that we regularly depend upon for day to day survival.

The four factors that will determine survival are

- Location
- Knowledge
- Preparation
- Luck

On doomsday most people will be living outside of areas that will be struck in initial attacks by blast or thermal radiation. Many others will already be living in areas that will never be damaged by blast or thermal radiation. Both of these groups, if they have the knowledge of what to do, and have made the proper preparations, will very likely find themselves in the group of survivors who are living unharmed five years after doomsday when the surviving population has once again established some semblance of order and is once again multiplying and replenishing the earth.

Selecting and Designing a Shelter

MYTH #03: You can build an adequate shelter in your basement. Return to index

For a number of reasons, basement shelters do not offer the amount of protection that is commonly supposed. A proper analogy between them and a survival installation as described later in this document would be to compare a plank with a well-equipped and commanded lifeboat. This is not to say, that if someone finds themselves in the water from a sunken vessel, it is not well to advise them to grab hold of a plank and start paddling in the direction that one hopes there lies shore, if there is no better means of survival, such as a lifeboat, or raft.

Similarly, there is very little protection afforded (starting from the rooftop down) by a layer of shingles, a foot or two of light insulation (composed mainly of air-spaces for the purpose of retaining heat), a quarter to half inch of plaster board, some paint, a carpet on the floor, another layer or two of thin boards, and perhaps some paneling or ceiling tiles if the basement is finished. The distance between the roof and the basement (a two-story house offers more than a bungalow in this way) does allow some additional protection, but this factor, along with the combined density of all the matter described, would not equal more protection than would be afforded by six to eight inches of earth.

When, within such a basement situation, one starts to create an expedient shelter using, as is usually advised, such materials as bookcases and trunks (filled with earth if possible), there are certain design errors that are liable to creep in. Piling dirt or other material on the floor above will help but the greatest dangers will be from the areas outside the basement wall where the foundation extends above the ground. It is best to keep ones shelter at least three feet below the outside ground level, and to have at least three feet of soil above one's head.

The next most overlooked problem is that of proper ventilation, so as to avoid carbon dioxide poisoning. As stated before, most survival experts advise a location other than the basement for such reasons as the threat of carbon monoxide poisoning in case of fire, broken gas mains, and the threat of fire itself that may result from the wide spread firestorms caused by the thermal radiation associated with a nuclear blast.

There are certain advantages to a basement shelter. One may have access to necessities such as food, clothing, and blankets stored in the home. There may still be water available from the hot water tank. And, most importantly, one may feel certain psychological comfort by being in the familiar surroundings of their own home. None of these advantages of course hold a candle to the advantage of being in a properly equipped and manned survival center.

MYTH #04: You must filter the air coming into a shelter to remove the fallout. Return to index

One of the general misconceptions regarding fallout and fallout shelters is that the air itself may become radioactive. This is simply not true. Those with a little learning will then say "Ah, yes, but it will contain radioactive particles of fallout". That is true, but a properly designed air intake, even for an expedient shelter, will cause most of the particles to drop out of the air flow before the air enters the shelter.

Should the number of particles still suspended in the air be a problem, an expedient filter, such as a damp sheet hung in the air intake passageway, will do an adequate job of filtering the air.

If the air vents do not have automatic blast valves then the air passage should be quickly shut and remain shut for a few minutes after the brilliant flash of a nearby nuclear explosion (so as to prevent the popcorning effect described earlier). The air passages will have to be shut in every case where there is a large fire nearby that is generating carbon monoxide that would otherwise seep into the shelter.

Most expedient shelters will not have precautions such as those just described. The danger of carbon monoxide poisoning is one of the main reasons that most survival experts recommend that even if one has a basement in their house it is preferable to build an expedient shelter a considerable distance outside and away from existing structures in case of fire.

MYTH #05: Water would become radioactive. Return to index

As has been mentioned before, the materials necessary for building an airpump, and an expedient radiation detector, are available in almost every home. Anyone planning on attempting to use the basement survival method should obtain ahead of time the detailed instructions for building these devices, and store these instructions in their home, along with an emergency supply of food and containers for storing approximately 14 gallons of water for each individual that is going to be accommodated.

There is a similar misconception about water becoming radioactive as there is about air becoming radioactive. This may have something to do with misconceptions about the nature of *heavy water*, but we won't go into that here. Radioactive particles do become suspended in water, however, and that is why for the shelter confinement period, you must make sure that you have a sufficient store of potable water available ahead of time.

During the recovery period, after radiation has decreased to the point where it is safe to work outside, there are techniques for letting fallout settle out of water, and for distilling water, in order to make sure that it is safe for drinking and cooking. However, far from keeping air and water out of a shelter, it is absolutely necessary to life that they be available.

While an expedient shelter could mean the difference between life and death, it is probably not something that you would want to continue to use for a very long time.

MYTH #06: There would be no dangerous radioactivity after a couple of weeks. Return to index

There is a wide range of misconceptions about what is safe and what is not. The matter is sufficiently complicated that a person should have professional advice. However, if there was no doctor going to be available to set a broken leg I presume you would go ahead and do the best you could. And if one had to build a bridge to get across a river and there was no structural engineer around, again I presume one would have a go at it.

Doctor's would like to have their x-ray machines available when setting a leg, and engineers would like to have their surveying equipment, specification guides, and computers or slide rules when they are building a bridge. So you can well imagine a radiological defense officer would like to have radiation detection equipment available when giving advice in a radiation defense situation.

However, if the advise, expertise, or equipment, is not available, one must go on. One rule of thumb is that if there is not enough fallout that you can see it, then there is not enough of it that it will kill you. Fallout is usually small grain dust or grit, often having a light color, but not always. It depends upon its source. The best place to spot it is on a smooth surface, like the hood of a car. The more dense fallout is, probably the greater the hazard, although there isn't necessarily a direct correlation. It may fall thick enough that quite a little heap of it may be brushed up from a surface that is one foot square. It is possible to build, from common materials found around the home, an expedient radiation detection meter. The details for such a meter are found in books listed in the bibliography.

Even if one has commercially available radiation detection equipment there is still some considerable skill required in its use. For example, almost all survey equipment is designed to be used by an adult of normal stature. This means that if the equipment is held in the hand of a walking adult it will tell how much radiation is being received 3 1/2 feet above the ground, and particularly by the adults vital organs which are above that level. A child's or an infant's vital organs will be below that level and will be exposed to much more hazardous levels than an adult's. For this reason, if one is passing through an area that is suspected to have any radiation at all, a child should be carried on an adult's shoulders.

There is another rule of thumb that for every seven fold increase in time radioactivity will decrease by ten fold. This is called the seven/ten rule. This is based upon standard decay. It is useful as an example, for training, and in building theoretical models, but in actual practice the decay rate is likely to be something quite different. It is determined by the isotopic composition of the matter under consideration.

There is another commonly held misconception among semi-trained individuals that low levels of radiation cannot be rapidly fatal. Someone, after several days in the confines of a cramped expedient shelter, might conclude that because their meters now indicate a very low level of radioactivity (or perhaps no radioactivity if it is a high-range instrument), that it would now be all right to go outside and sleep on the ground in the cool breezes beneath the bright summer stars. The fallacy again arises from taking measurements at a level that assumes the vital organs are well above the radiation source. This is not the case when a person is stretched out on the ground for long hours of sleep. These long hours of low level radiation exposure to the vital organs will result in a fatality in just a few days.

Likewise, perfectly healthy adults who take infants out of the cramped, unpleasant, expedient shelter to allow them to play during the day on a blanket spread out on the ground will be quite shocked to see those infants sicken and die in just a few days while they themselves remain healthy. The infant's vital organs again being close to the weak radiation source for a long period while the adults' vital organs are being protected by distance.

MYTH #07: Radiation sickness is not contagious so there is no danger in assisting those affected. Return to index

The statement that radiation sickness is not contagious is often found in the literature. That is true. The erroneous conclusion is drawn, however, that being around persons with radiation sickness is not dangerous. The danger arises from the manner in which radiation kills.

Sufficient radiation can cook the vital organs, but more often what happens is that it kills the white corpuscles and the ability of the bone marrow to make more of them. It is the white corpuscles that are the body's defenders against viruses, bacteria, and other disease causing bodies.

Once these defenders are lost the person succumbs to a disease they might have otherwise warded off, and once that disease takes hold in the individual they may become highly contagious.

In this manner there is grave danger of plagues breaking out, and all sorts of illnesses one does not generally see, becoming very threatening. For this reason rigorous quarantine, sanitary measures, and health defense measures must be imposed and enforced.

Becoming aware of such unexpected and unpleasant snares may initially make one feel that the situation is hopeless. The danger really arises from a person's unfamiliarity with the circumstances. There is the story of the explorer who asked the young native if there were crocodiles in a certain stream. He was assured there were not. While then swimming in the stream he once again saw the young lad on the bank and asked for reassurance that there were no crocodiles. "Oh no sir!", replied the shocked young fellow, "They won't come here. They are all afraid of the piranha."

The young fellow would have found himself equally in danger from things with which he was not familiar in our society, like automobiles and electrical appliances. It is not that the hazards are so onerous, but simply that we are not familiar with them.

FOOD - Some Important Considerations

MYTH #08: Food exposed to radiation becomes radioactive and is therefore not edible. Return to index

Food is the most serious problem. Most food that is in the house will not be harmed by the radiation, no matter how intense. There are three types of radiation that are found in fallout. Alpha particles, beta particles, and gamma rays. As the first two names indicate, they are particles. They are minute (too small to be seen) pieces of atomic matter that attach themselves to the fallout (bits of dust that may or may not be large enough to be seen).

In any case, these particles may be simply washed off many types of foods that have a natural covering, such as eggs, bananas, potatoes, oranges, etc., or off well sealed foods such as those in vacuum packed cans. Foods such as grains (rice, dry cereals, etc.) that are in partially used packages that have been opened should be viewed with suspicion. Fallout dust may have crept in. The food in its unopened container or natural covering should be rinsed under flowing water and then placed on a surface that has been similarly cleansed, before opening. Make sure that the hands (and under the nails) have been thoroughly cleansed before handling the food. There is little danger in handling such articles. The radiation given off by these particles is so weak that it will often not even penetrate something as thin as the cellophane wrapper on a package of cigarettes.

You may then ask "Why, then, be concerned?" The reason is that once these minute particles are ingested into the biological system they will get into the organs and the very bone marrow itself where they can do a lot of damage. This is not to say that you need not worry about getting the alpha and beta particles on your skin. You do. Because they can cause skin burns. However, good hygiene practice can eliminate that problem but they are a much more severe hazard internally than externally.

MYTH #09: If you have a special *radiation suit* like you see in the movies and on TV you will be protected from the radiation. Return to index

As an aside, this is one of the reasons that those *fallout or radiation suits* that you see in all the pictures and movies and on TV are such a **joke**. Those things are not going to protect the guy from anything, that a couple of good garbage bags wrapped around his feet and made into a hood to go over his head, would not do as well. In fact the garbage bags are in many ways better. They would be considered disposable.

The main purpose of the fallout suits is to prevent the wearer from tracking the fallout into the shelter. The user simply takes the suit off at the door. If the person were to wear it on inside, it would defeat the purpose. There are some clean handling techniques that are beneficial to know and practice, but in a wartime situation there is so much of the stuff around that peacetime standards of exposure and cleanliness lose their meaning.

The gamma rays are another matter. They are very penetrating. No fallout or radiation suit is going to protect you from them. It requires much more dense matter to protect you than you could lift, let alone lug around. This is why one must remain in a shelter when there is intense radiation. With good housekeeping there should not be so much dust inside a shelter as to create a hazard from gamma rays. However, be sure to dispose of the contaminated rinse water that you have used for cleaning the food containers and persons returning from outside. It may contain matter that is giving off gamma rays.

There will probably not be sufficient fallout on the food packages (or you can get rid of it quickly enough) that you need concern yourself about the amount of gamma radiation that you are going to get from that source during the decontamination process. However, the food may have been stored in an area that has received very intense radiation. That can of beans or peaches may have been stored right out there where it was receiving 1000 roentgens of radiation per hour. An amount that would have killed you right away. But it will not be harmed.

That is right. It is perfectly edible. If it were not so I would have told you. It is only living things that radiation hurts. Even then it depends upon the frequency and intensity of the radiation. For example, there are all sorts of radio and TV waves going right through where you are sitting right now and they are not harming you.

The food in the can is already dead and the gamma rays are not going to harm it. They will not make it radioactive. If the radiation is strong enough it may kill any bacteria that happen to still be living in the food and thus preserve it even further. If the food is supposed to contain bacteria (such as yogurt) I am not sure what it would do for that!

Radiation preservation of food is a technique that is already being used in industry and will probably become much more widely used in future years. Many people already have radiation (microwave) ovens in their homes today. One further analogy. Fire will kill living animals but we use it to cook our food.

MYTH #10: New crops of food grown in future years will not be radioactive. Return to index

Food that is grown in radioactive soil, or that has not yet been harvested when, fallout falls on it is another matter. This food will absorb the particles of radioactive matter into its own structure and thus become dangerous.

The biological food chain acts as a marvelous strainer and concentrator of radioactive isotopes. This was well demonstrated in certain tests that took place at Almagordo. From some intentional surface bursts and because of the unintentional venting of some underground bursts there was some fallout carried onto the milkshed for southern Utah.

The amount of fallout deposited over the surface was so slight that the most selective instruments could not detect it. An atomic or nuclear explosion releases its great amounts of energy by changing some matter into energy. It also changes certain amounts of matter into new and different types of matter. Without going into detail about atomic theory, the nature of the atom with its electron rings, and its nucleus consisting of protons and varying number of neutrons, let us simply say that these new forms of matter are generally unstable isotopes. That means they are going to change into another form of matter.

Once again, the matter, in the process of changing from one state to another, releases certain amounts of energy. It is this energy that we measure as radioactivity. The energy, depending upon the isotope involved, may be rapidly dispelled or it may continue to be released for a very, very long time. Most unstable isotopes release their energy and transform into a stable state within fractions of a second or at least within minutes after a nuclear explosion. Others take hours, and still others days, weeks, or months. Some take centuries.

Each isotope starts out with just so much energy. For all practical purposes we can say it is not going to get any more. Once that isotope has released all its excess energy it will become stable. Since the isotope releases its energy at a specified rate we can say how long it will take to lose half of its energy. After that, it will then take the same length of time again for it to lose (give off) one half of the remaining amount of energy. Question: When will all of the energy be given off by the isotope?

An ancient Greek philosopher posed the same problem. He said, "Suppose there is a bear at the back of a cave. On the first day the bear walks halfway to the entrance. On the next day he walks half of the distance that remained to the entrance after the first day. And on the day following the bear walks half of the distance that remained to the entrance from the previous day. The bear continues to do this same thing on each subsequent day. He walks half of the distance to entrance of what was left from the previous day. The question is: when will the bear get out of the cave?"

The answer is: "Never." This sort of regression is what mathematicians call asymptotic. That is to say the figures continue to approach zero, closer and closer, but they never reach it. So just as the bear never gets out of the cave, all of the energy is never lost. But much (one half) of the energy is lost in the first half-life. And three quarters of the energy is lost by the end of the second half-life. After ten half lives a very large percentage of the energy is gone.

It is because so much of the energy is lost in the early periods (half-lives), as compared to the later periods, that it is important to be in shelter during the early periods after fallout has fallen.

We might divide the half-life times of radioactive isotopes into three categories. Very short term, medium term, and very long term.

As mentioned earlier, most of the unstable isotopes generated by an atomic or nuclear explosion are very short term. They give off all their significant amounts of energy in a matter of seconds. Unless you are within very close range of an atomic or nuclear bomb there will be no way for this radiation to reach you. It was this initial radiation that caused the horrible radiation burns and sickness at Hiroshima and Nagasaki.

First the good news. There will not be any persons subjected to long suffering from the initial radiation by the nuclear weapons of today. The bad news is that the reason why is that the weapons blast such a large hole or create such a large area of complete destruction that the initial radiation can't escape. That is to say the totally destructive blast extends beyond the range of the initial radiation.

On the other hand, the survivors of Hiroshima and Nagasaki did not have much problem with fallout. The first major victims of fallout were some fishermen many, many miles downwind from the Bikini Island tests. Fallout is a phenomenon much more associated with nuclear weapons.

Nevertheless, there was fallout in Southern Utah. As stated before, it was so slight it could not be detected by the most sensitive instruments. The specific matter of interest in southern Utah was the isotope 131 of iodine. This was absorbed by minute bacteria in the soil. In the process of filtering the iodine out of the soil the bacteria greatly concentrated it.

The bacteria were absorbed by legumes and other biological forms higher in the food chain. Each in turn further concentrated the iodine isotope.

Finally, after the iodine had found its way into the grass a cow came along and ate it. Now a cow is a very complex organism in itself. There are all sorts of biological activities going on in a cow. Various organs and the bone marrow filter out different minerals for different purposes. One of these complex systems forms milk. This particular cow, and hundreds of others like it, was milked, and the milk was bottled and distributed to children all over the area of southern Utah. The children were also complex biological organisms. They in turn had numbers of specific organs that specialized in straining out various minerals and compounds from the food that they consumed. The end result was that their thyroids once again concentrated the iodine 131. And this to such an extent that if you held a radiation detector next to their necks it buzzed like a rattlesnake. This was not healthy.

In fact numerous problems developed among the population. There were a great number of mentally retarded children born, and a number of other unpleasant ramifications. This need not have occurred from the iodine 131 if we had known what we know today.

MYTH #11: There is no such thing as a fallout pill. Return to index

There is a simple pill that would have prevented the difficulty. It is supplied in every nuclear emergency kit in Russia and available in Denmark and Sweden. Unfortunately it is not widely sold in North America.

Fortunately, however, the pill is quite simple to make. Ahead of time, obtain a quantity of potassium iodide from your local drug store. Five dollars worth should be lots. When needed, take a regular glass and fill it a fourth or less full of water, and then slowly start pouring in the potassium iodide while thoroughly stirring the water.

Don't worry about how much you pour in. You cannot pour in too much. After a while you will notice that the chemical no longer dissolves in the water. It just lies there on the bottom. This means that the water is saturated. You can now stop pouring in the chemical. More will not help or hurt.

Next take an eyedropper, or a soaked piece of paper if you do not have an eyedropper, and drop four drops onto a little piece of bread for an adult. Or two drops for a child. If you get several times that amount it is not going to harm you (although in much larger amounts it is a poison). Now take some butter or margarine and make a little ball out of the bread and pop it down. Tastes awful. Ugh. Take once a day for 100 days after the last bomb falls. This is good stuff and you should have it around for reasons other than defense in case of a nuclear war.

If you live anywhere within in a couple of hundred miles of a nuclear generating plant you might suddenly find yourself needing the stuff. The US department of Health rushed a supply of pills to Three Mile Island and they have a standard brochure all printed ready for distribution in case it or some similar site vents.

The department of defense also keeps a supply near the old Titan sites that are deteriorating and breaking down. [Author's update note: Once again those sites have been now decommissioned and no longer present a problem, but much greater concerns now arise from Terrorist Threat, and the U.S. Government is now stockpiling in many cities not only these pills but others for Bacteriological and Chemical Threats]. Canadians have nothing. I'll take that back. They do have lots of nuclear plants and the distinct possibility of bombs exploding over their heads and on their soil.

The reason why the potassium iodide works is that the thyroid will absorb only so much iodine. After that, any iodine taken into the body is passed off by the kidneys. Since the body already has all the good stuff it wants it passes out the bad stuff. This is what we call thyroid blocking.

Do not try to use the tincture of iodine that you put onto cuts. Taken internally it will kill you. And you cannot eat enough iodized salt to do you any good. You would get salt poisoning long before you got sufficient iodine to do the job.

MYTH #12: There is a fallout pill that will protect you from all radiation. Return to index

I wish I could tell you about another pill that would solve all your radiation and other problems. But there is none. Unless you mean the cyanide pill mentioned earlier and things really are not that gloomy. As I hope I have carefully explained, most of the radiation we have to be concerned about from a nuclear bomb will decay in a matter of days or weeks to a level where we can deal with it.

MYTH #13: There would be dangerous radioactivity for thousands of years. Return to index

You may say "I've heard that some radiation will be around for thousands and even hundreds of thousands of years". Yes, but those isotopes are our friends. (That may be putting it a bit strongly.) Anyway, they are not near so harmful as many people think. There is the point of view that no radiation is good for you. Some dermatologists maintain that you should not even get a suntan. (Yes, that is radiation that you get from the sun.)

There is even the theory that it is cosmic radiation that causes both overall genetic change, aging, and death. In any case we are all subjected to many sources of radiation every day. The question is not whether or not you are going to receive radiation, but how much and how quickly. Let us compare the radiation we are concerned about with another type of radiation. Heat.

Just as we measure radioactivity in roentgens we measure heat in calories. If I were to tell you that that pipe over there was going to put off a million calories of heat, you might say, "Let me get away from it!". But, if I then said that it was going to be over the next million years, at the rate of one calorie per year, you would realize that you were in greater danger of freezing to death than of burning to death if you were depending upon that pipe for heat.

It is not how much heat is going to be given off (it may be a large amount) but how much over what period of time. A mere two hundred calories suddenly inflicted upon one point of the skin would create a bit of a sting, but hundreds of thousands might be comfortably absorbed from a heating pad over an appropriate period of time.

It is the same with radiation. Most isotopes give off their energy so rapidly that they are like flash bulbs. Flash and they are gone. It just happens right in the vicinity of the bomb. Others are like regular light bulbs that give off their light and heat for some period of time before they burn out. They may travel a long way from the bomb as fallout before they dissipate their energy. For these we need a shelter to protect us if we are in their vicinity. Nothing else will do.

Still others are like those small luminescent lights that some people put in their bathrooms for night-lights. Only weaker still. They just sit there and barely glow for a very long period of time.

Little miniature flashlight bulbs or matches are a good analogy to fallout particles. One or two of them in a room with you will not harm you. But surely you can imagine the situation where if you had thousands and thousands the light would either be blinding or the heat so intense that you would be incinerated.

Fallout is just the same way. A few pieces inside a shelter with you will not harm you, but if you go outside where there are millions of the little beasts lying around then you have had it. The only difference between their radiation and the radiation from a little flashlight bulb or a match is that it is invisible radiation that you cannot see or feel - like that from an x-ray machine.

MYTH #14: There would be no dangerous radioactivity after a couple of years. Return to index

After having explained all this, now I must tell you that there are some isotopes that unfortunately do not fall into either the short range of initial radiation (which we do not need to worry about because it does not extend out of the blast area), nor the medium range (that you will be protected from by a fallout shelter), nor the very long range (that decays over so many hundreds of years that their energy is too weak to concern us here).

These remaining isotopes are real meanies. There may be solutions to the problems they present but there are no simple solutions. There will not be enough of them around that they will make walking around dangerous for most people but the problem is that they get into the food chain and that they have relatively short half-lives, between five and 30 years.
That means that during the next couple of hundred years they are going to be giving off most of their energy. Fortunately, some of them are rather rare, and given that they are going to be widely dissipated in worldwide fallout we can largely ignore their effects.
Others may be concentrated in certain areas, certain types of soil and certain foods where we can avoid them also.
So they will not be that serious a problem.
Some others, however, particularly Cesium 137 and Strontium 90, present major problems in keeping them out of the food chain. Even here, there are available defense techniques. For example lime, gypsum, fertilizer, or organic matter (in practical amounts) may be applied to low calcium soil, or naturally high calcium soil may be used for growing certain crops which have an uptake preference for calcium over strontium.
There are known refining and purification techniques for some foods and milk, and there are some new techniques which I have discussed with some of the researchers at some of the leading nuclear laboratories, but which the world isn't ready to hear about as yet.
These methods along with others such as land denial, deep plowing, surface scraping, and selective utilization, are harsh realities that are going to have to be faced by the long-range survivors.

MYTH #15: You are prepared if you have a two weeks emergency supply of food stored.
Return to index

More important to the present theme are questions as to what preparations survivors should be making ahead of time. Since it will take a while to get crops growing again because of social disorganization, ozone depletion in the atmosphere, climatic changes, crop adaptation, early crop failures, soil deprivation, and similar factors, survivors will need a couple of year's supply of food. Wheat and honey are the only two basic foods, of which I am aware, that have an indefinite shelf life. Thousand year old kernels found in the pyramids have still sprouted. Fortunately, these two foods, wheat and honey, meet most adult nutrient requirements. Powdered milk will be necessary if one wishes to reduce the infant mortalities. The infants will not survive otherwise, unless their mothers have adequate natural milk, which is unlikely. Salt is important as a preservative, among other purposes.
In addition to storing the four basic survival foods (wheat, honey, powdered milk and salt), it is highly advisable that one also store a couple of year's supply of a variety of (non-hybrid) seeds. Some seeds will not store very well and need to be continually replaced.
It is equally important to develop certain skills. *Gardening skills*. I particularly recommend the area of hydroponics because this would be one way to grow foods free of contamination. *Preserving skills*. Here I recommend learning to dry foods using hot air. Freeze-drying requires too much elaborate and expensive equipment and freezing itself is not reliable when electricity is not reliable. *Preparation skills*. Bread making, use of lentils, and making of many foods, or their substitutes, that today are commonly gotten in prepared form.
On all of these subjects one could write a book. Indeed many books have been written on them. Even if one does not have time to immediately develop all these skills they might do well to get themselves a survival library and then as a next step acquire the essentials in materials listed in checklists in most well organized manuals.

MYTH #16: You should be prepared to be self-sufficient and be able to survive on your own. Return to index

The very best thing that a survival minded person can do, after preparing for themselves an equipped place of refuge, and developing their own survival skills, is to associate themselves with other skilled survivalists. No one person can know everything, and almost everyone can contribute something. Agricultural, medical, mechanical, communicator, you name it, all skills will be needed.

Few people could afford the equipment that an organization can have. One well-equipped laboratory for testing for alpha and beta particles in food costs $5,000. Along with other radiation detection equipment and many other types of emergency supplies, what individual can afford it? Yet no nuclear survival group should be without one.

Even in building a shelter the major expense is the entrance and support mechanisms such as emergency lighting, water source, etc. The incremental cost for space for one additional individual is quite small. Thus, the greater the number of people the overall cost can be spread over, the less the average cost.

Moreover, no individual has the personal resources that a group has. If the head of a single family survival group is injured or lost the chances of survival for that group are much reduced. However, if it is a large group then there are numbers of people available to continue to give support. Just like there are numbers of people available to maintain twenty-four hour watches, or to create a well manned convoy to go after necessary supplies. One more prepared and equipped individual added to such a group is an asset, whereas in a situation like a public shelter, one more unprepared and unequipped individual is just another liability.

A successful survival group will have to be either completely homogeneous or thoroughly committed to tolerance and appreciation of a wide range of individual preferences regarding society, economics, religion, and future expectations. Still, a shelter is not a democratic society anymore than is a ship or an airliner. The captain's authority is absolute and one should have confidence in his credentials and ability before boarding.

Neither is a shelter a democracy in the sense that there must be much more stringent rules regarding behavior. Everyone must perform assigned duties. There are no wealthy passengers along for a free ride to be served by others. There are many limitations to personal freedoms such as contraband materials. No drugs or alcohol (except under medical prescription and then as approved by the commander).

All firearms and weapons must be placed in the armory and will not be released except under orders from the commander. All valuables will be receipted and stored in the locker for safekeeping. No private stocks of foods because under survival conditions this can lead to social disorder. No tobacco or smoking inside the shelter, since it would cause discomfort to others. No loud toys, devices, or other objects that would be environmentally disturbing to others. No large bulky items, or great quantities of any item without the permission of the commander. And no pets or animals unless the survival community has made prior special arrangements for their accommodation.

Tough. Yes, It is tough. But not nearly as tough as the conditions of survival will be for those who are not prepared. There are many items that are not prohibited, and in fact are encouraged. A reasonable supply of one's personal religious literature, the tools and resource manuals of their trade or profession, survival manuals and equipment of every sort, additional supplies of food to be put into the common larder, and extra supplies to be put into the common store.

MYTH #17: Any survivors would have to live the rest of their lives underground. Return to index

Many people ask how long they might expect to have to live in a shelter. There are no fixed answers. If your shelter is an expedient hole in the ground you might want to stay in it no longer than was absolutely necessary. Maybe as much as a couple of weeks. If you dug a pretty elaborate hole in the ground you might be able to expand upon it and make it into a place where you could survive through a winter.

If you owned space in a shelter city, like there is in southern Utah or southern California, you might plan to live there the rest of your life. The co-operative shelter that I have been describing in the previous paragraphs is not sufficiently elaborate that anyone would want to make it a permanent home. Some persons would probably be able to find larger and more adequate quarters elsewhere after a few weeks.

Others might improve upon the existing structure and remain there for a year or two until more adequate homes could be built elsewhere. Decontamination procedures would provide work areas, schools, and school grounds outside of the shelter where people would carry on their daily activities after a few weeks. However, it might be beneficial for young children and expectant mothers to sleep in the shelter or a similar structure for several months.

Certain occupations, such as decontamination crews, farmers who work on large un-decontaminated areas, explorers who go into unsurveyed areas, long distance truck drivers, and others who go out of well defined areas for the next several years, will have to be closely monitored to be sure their total exposure does not exceed established limits.

It should be apparent to the reader, from what has been said earlier, that a person may receive substantially larger total doses over a large period of time than over a short period of time, just as with sunlight. A person may easily recover from several small sunburns throughout the years, resulting from staying in the sun overlong for an hour or two each time. If they were to be exposed to the hot desert sun, that many hours all at once, they would succumb.

In the same way one may recover from a number of small radiation burns (although some controversy holds that one never recovers - this seems unlikely), and in just the same way one may receive small amounts of radiation and never feel ill. Just the same, certain biological conditions dictate that certain individuals, (particularly the reproductively active) should receive less radiation exposure and that others may receive much larger amounts.

MYTH #18: Life after doomsday won't be worth living. Return to index

Hearing descriptions of this sort some persons wonder if life will be worth living afterwards. For some, most assuredly so. Others do not find life worth living today. How many times have you heard of a person like a famous movie star, who had wealth, fame, beauty, health, the company of famous illustrious persons, opportunities to travel to all sorts of places, and to participate in all sorts of interesting events, the fulfillment of the very aspirations of thousands of young ambitious people and yet that same person committed suicide.

On the other hand there are many individuals who suffer daily from terrible physical afflictions and all sorts of personal misfortunes. Often times in the greatest poverty. And yet, the world over, down through the centuries, they have gone on surviving. Many actually find happiness, meaning, and perhaps even enlightenment in life. You will survive. The conditions of that survival are up to you.

Undoubtedly, the events that are about to transpire will have a profound effect upon the attitudes of many people and perhaps upon mankind itself. From the cauldron of the holocaust there may spring forth a new race of men who are less concerned with self-interest and who will come to understand man's true nature and his divine destiny.

Some of us may even feel that this event will herald the coming to maturity of the human race. Instead of no future, mankind may have a glorious future. There will be great amounts of resources available, combined with man's great advances in technology, to build a new and glorious world civilization. Providing, of course, that he has learned from this experience and does not just go about preparing for the next war in another twenty to thirty years.

But, I leave each man unto his own vision. While, to myself, looking upon the immensity of the visible universe, and pondering the events that have happened upon this one single planet circling a solitary sun among the uncountable millions in our but one of the innumerable galaxies, I cannot help but wonder if the events that are about to transpire are not less than all that unique in the repetitive cycles of life and nature that we see about us everywhere.

MYTH #19: You need not make any preparation because you are either going to die in the holocaust or be *saved* (religious connotation). Return to index

Men's philosophies today often go to one extreme or the other. Claiming that all is within man's power. Or that nothing is within man's power. There is a middle ground. One can simultaneously feel that nothing can be achieved except by the will of God and think that the results are dependent upon his own efforts. God sets the boundaries and within those boundaries man can have some effect upon the outcome.

MYTH #20: The bombs today are so large and there are so many they will destroy the world. Return to index

There are those who feel that the holocaust will destroy everything. And well it might, for there are certainly more than enough nuclear weapons in the world to achieve that end. "Except those days be shortened, none will survive, not even the very elect." But, if it is the Divine Will, those days will be shortened. There are those of us who feel that the Divine Hand is evidenced in the dealings of the world, every moment unto every moment.

The Divine happenings often seem quite natural. If one were to say unto a mountain, "Be thou removed and cast into the sea." and it should occur, another would say an earthquake just happened to happen right then. If the forces of nature should transpire so that in the midst of the holocaust the planet should suddenly tip on its side and place His sign (the Southern Cross) suddenly blazing in the sky above the heads of the people in the northern hemisphere, there are those who would only recognize the natural causes.

Such an event would certainly play heck with the astral, satellite based, and inertial, guidance systems upon which the individual and MIRVed warhead delivery systems depend.

Events would not even have to be as miraculous as I have described in order to limit Word War III. There is serious concern on the part of the military that they will not even be able to fight the war because of such factors as the EMP. However, I have faith in the military. I am sure they will do an admirable job of trying to destroy the world.

None of us have an infallible insight into the future or its timetable. Whatever will be, will be. We can but wait upon events to prove our speculations to be right or wrong. While we are working and waiting some of us put our trust in God. Others put it in the Government.

MYTH #21: You will receive adequate warning from your government. Return to index

The government at first proposed the individual family shelter plan. Then it abandoned it. Next it proposed the community shelter plan. Then it abandoned it. Then it proposed the relocation plan. Then it abandoned it. Presently it has no plan. Don't you feel abandoned?

The government has millions to spend for destruction but not a penny for defense. The EMO (Emergency Measures Organization) has been completely shut down. The Ontario government was allocated three berths in the Radiological Defense Officers course (for the summer of 1982) given by the Canadian Emergency Measures College at the Emergency Planning Canada Federal Study Center in Arnprior, Ontario, but it didn't feel it could afford to send anyone even after our group offered to pay expenses for three people. We appealed all the way up to the Solicitor General's office.

Admittedly, I am authorized to teach the course but during the last course that I taught at one of the community colleges (free gratis) I could not even get any resource personnel to come from Camp Borden, who are responsible for administering the examinations. I feel abandoned. A radiological detection kit that I used to be able to get for sixty dollars, in the US, now costs in Canada, with import duties (they really want you to have one), federal and provincial taxes, exchange rate, custom's brokerage, and you name it, $450. Who cares?

The last Radiological Scientific Officers Course taught in Canada was in 1977. No future courses are planned. There are no communities with a nuclear defense plan. I think I can make that an unqualified statement.

Millions for destruction and not a penny for defense. Your family's destruction bill for this year is $1,300 per member of your family. Do you realize what $1,000 a year for the last ten years would have bought you in the way of nuclear survival defense? Instead, your government has bought you destruction. Your family's destruction.

Oh, I am well aware of the argument that that pile of bombs has maintained peace in the world for the last ten years, and the belief that it will continue to maintain peace. Believe it if you want to.

All the high government officials have their shelters. Why do they need them if you don't? [Author's update note: Curiously, even the government's shelters for civil authorities have now been closed].

If the government knew today that the Russians were going to attack next week, do you think they would tell you? If they did, what would you and the millions like you do? It would only create panic and get in their way. No, I do not think that you would be told. Do you feel abandoned?

MYTH #22: You will receive no warning, and there is no hope if you do. Return to index

The fact the government may not warn you, and is not giving you any assistance to defend yourself does not mean that you haven't been warned. There are many people who feel they can see the *signs of the times*. Anyway, if you have read this document, consider yourself warned. You may still have time to prepare. If an attack should occur you probably do not live in a primary target area and will have plenty of time to escape. If you have made preparation.

MYTH #23: One of the primary targets will be nuclear power plants. Return to index

Many persons come up with all sorts of rationalizations as to why they should not prepare for survival. One is that there is a sufficient number of weapons in the world, that if they were all used, they could destroy the whole of mankind. This is true.

However, it may be that all the weapons will not be used. Some may be destroyed by the other side. Some may misfire. Others may just fail to get launched. This is why each side has so many extra. Moreover, many persons make the mistake of assuming that it is all in man's hands and determined by man's will. Whatever. It may be that some limited amount of the potential for destruction will be used.

Another rationalization often heard is that the person feels they live in a target area such as in the vicinity of a nuclear generating plant. In actuality the Russians have little need to target the nuclear generating plants and probably can do more damage by not doing so. A bomb on the plant would just blow it to smithereens and the material in the plant might add little to the radioactive fallout. On the other hand, as a result of the EMP, if the plant is left on its own when it loses its computer control it will go into a meltdown and add substantial radioactive material to the atmosphere.

All of this is quite speculative, of course. There are no experts on nuclear war. There is no one living who has been through one. There is general agreement that it will be awfully terrible. It will probably take six or seven months just to bury the bodies. But, there will probably be someone around to do it.

Useful Figures and Tables

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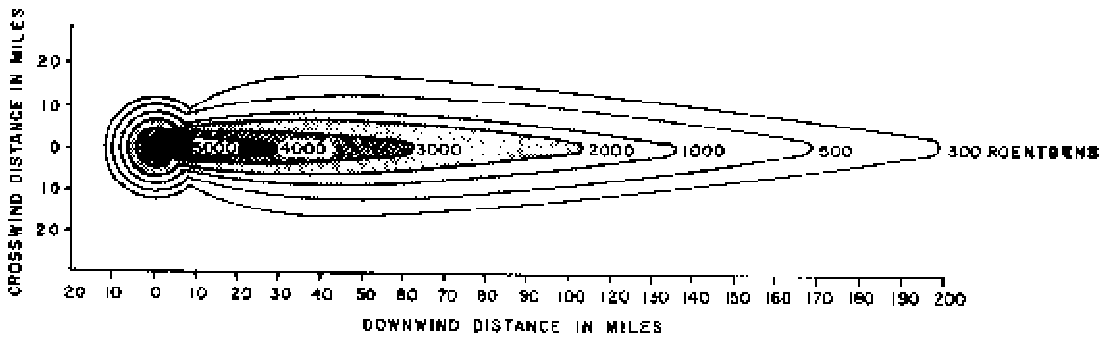
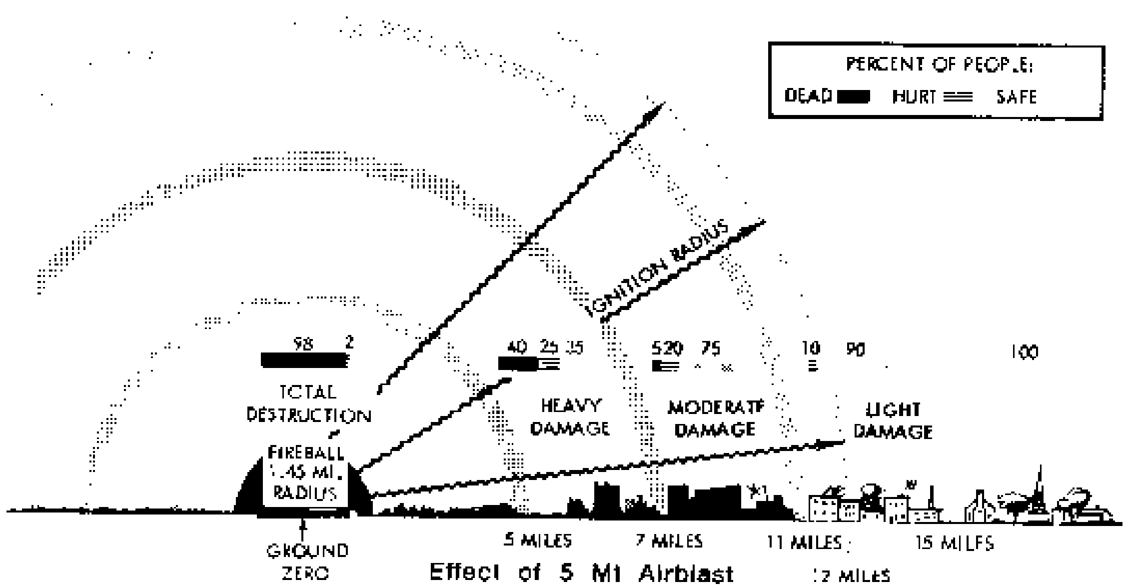


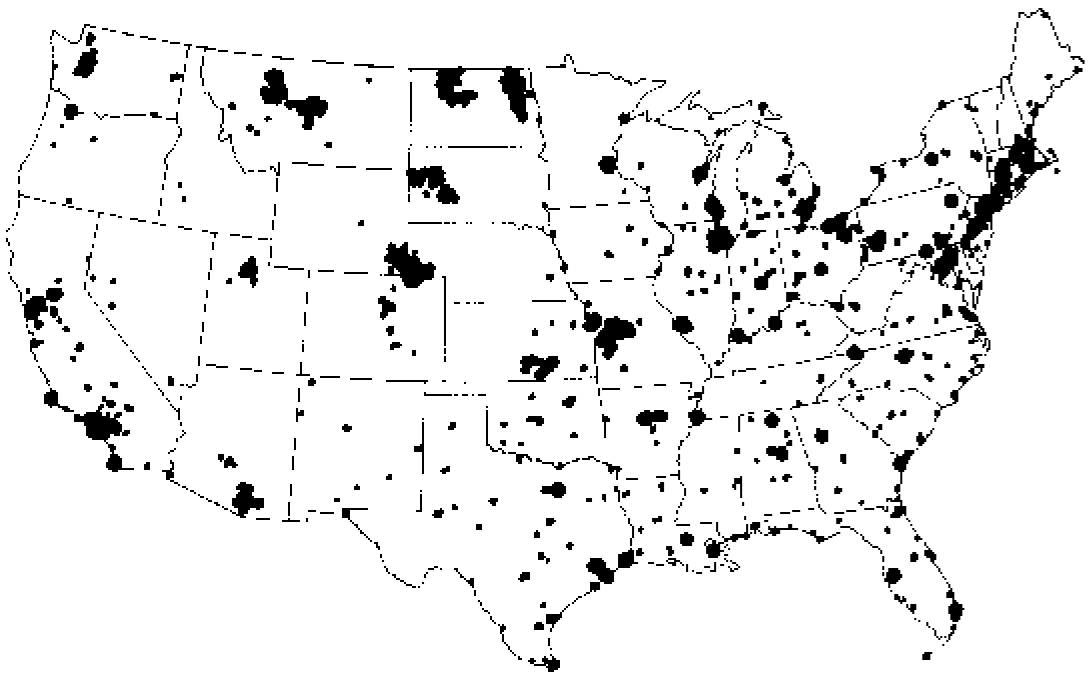
This was the fallout pattern 36 hours after a single 15-megaton thermonuclear device (the Bravo shot of Operation Castle at Bikini Atoll - March 1, 1954) was detonated. The eventual extension of the fallout was more than 20 miles upwind and over 320 miles downwind. The width in cross section was variable, the maximum being over 60 miles. This means there was substantial fallout contamination over an area of more than 7000 square miles.

It is important to note that persons anywhere downwind would not have had to travel more than 40 miles in a direction crosswind to be perfectly safe. Secondly, assuming upperwinds of 150 miles per hour and descent times of 30 minutes, persons 150 to 200 miles away would have over an hour in which to either evacuate the area or to take shelter.

As noted from the chart on the effects of radiation on humans, the 300 roentgens per hour would cause serious illness with some fatalities after an exposure of 1 hour and exposure of 2 hours would certainly cause a hard death occurring in hours to days

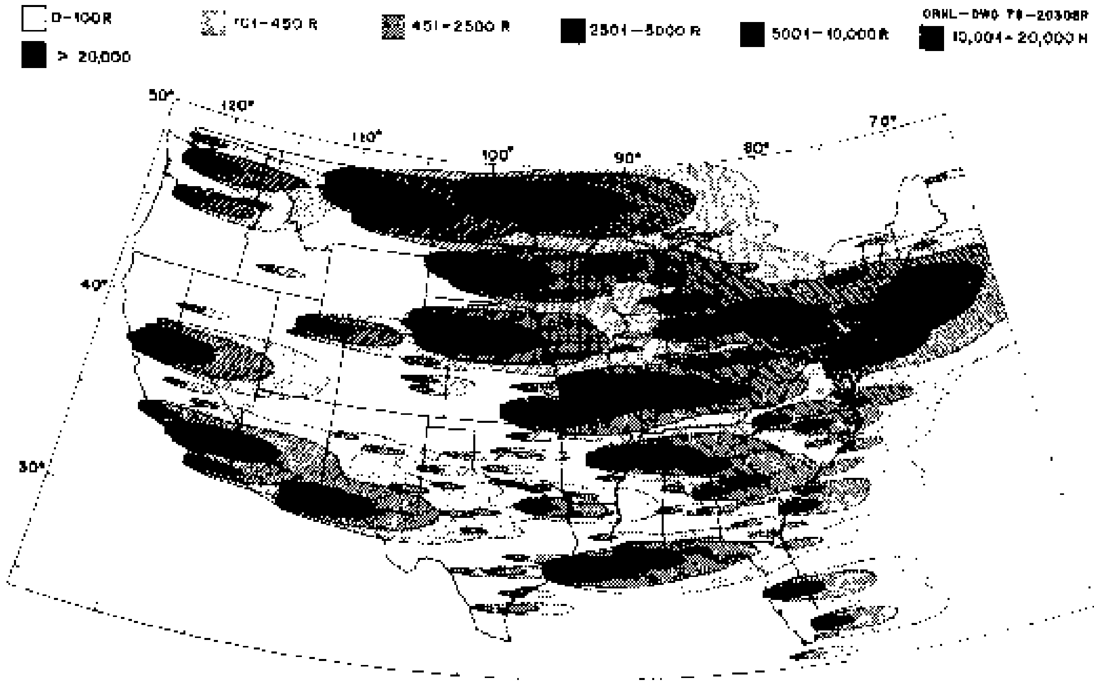


The previous picture shows the effect of a 5-megaton air-blast. While much larger weapons have been developed experimentally their use is unlikely. For one thing they are too hard to deliver and, more importantly, with a 20-megaton weapon we do only about one third the damage that will be caused by 4 five-megaton weapons. 5 to 8 megatons will probably be the average size of the strategic weapons. They will probably be detonated at some altitude around 2000 feet for maximum effect. At 15 to 18 miles on a clear day exposed people will be blistered, and from 18 to 23 miles they will be sunburned.

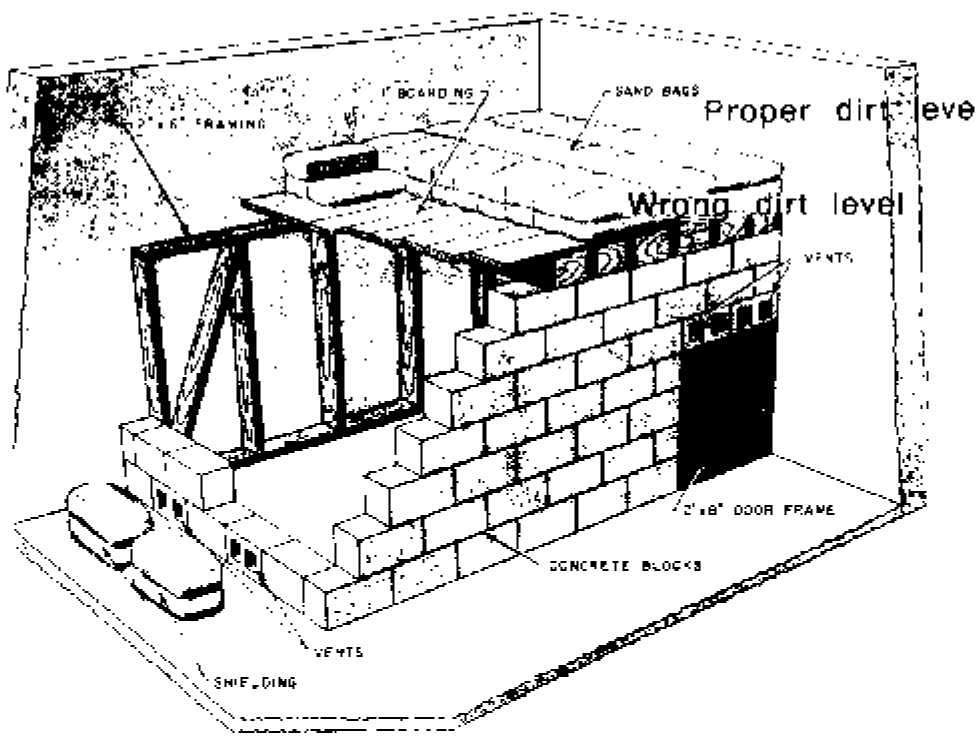


This map shows the principal targets in the US. Major airports, military installations, and railway passes would be targets in Canada. The number two target in North America is North Bay, Ontario.

In an all out nuclear exchange (WW III), with a multiplicity of devices being detonated over a relative short period of time (three days to two weeks is a common estimate), there would most likely be wide spread areas with general radiation levels (in the 5 to 20 roentgen per hour range) over 1000 miles down wind from the blast sites, two to three days after zero hour.



This map indicates the amount of radiation that a person would receive in various areas by remaining in the open for 14 days following the bombing of targets indicated in the map above. It is important to note from the map that even if Canada were not bombed that Ontario would receive 101 to 450 roentgens from the MinuteMan sites in Montana and the Dakotas.



The effect of a mere 10 roentgens per hour (arriving two or three days after a detonation and thus having already lost much of its rapid decay) would cause serious illness after one day's exposure, and (even with continued decay) would cause certain death within a couple of weeks. However, almost any expedient shelter would greatly minimize the effects.

The basement shelter shown here could mean the difference between life and death. As much care as possible should be taken to make sure the shelter roof is below outside ground level. Otherwise, radiation will come in at an angle through the narrow basement wall, as demonstrated.

Seven/Ten Rule

1 hour ------------------ 1000 roentgens/hour
7 hours ----------------- 100 roentgens/hour
49 hours (2 days) -------- 10 roentgens/hour
2 weeks ----------------- 1 roentgens/hour
14 weeks ----------------- 0.1 roentgens/hour
98 weeks (2 1/2 years) --- 0.01 roentgens/hour

This chart indicates that if one started off with one thousand roentgens of radiation per hour at zero plus 1 hour, that it would take 2 weeks for the radiation to get down to 1 roentgen per hour. Since death would be almost certain after exposure for even 1/2 hr (see accompanying chart) it is apparent that shelter would be necessary.

The important thing to remember about the seven/ten rule is that it is only theoretical, and that actual decay may follow a different slope. Secondly, in order to use it. One must know the exact time of detonation for the weapon causing the fallout. And thirdly, it is only applicable for calculating the fallout from one weapon, and not for multiple sources.

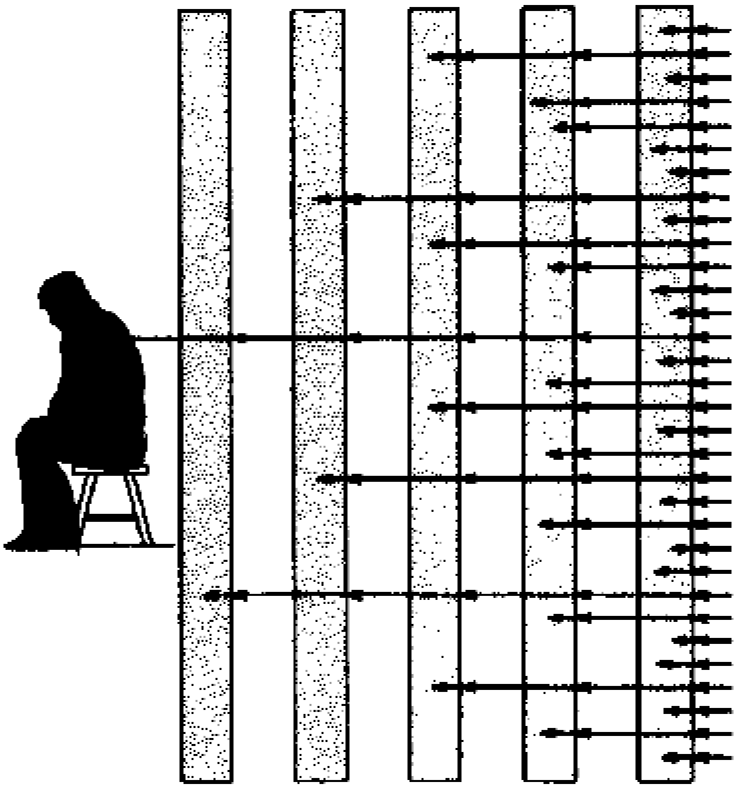
Examples of the Effects of Radiation on Humans

Roentgens per hour	Duration of exposure	Total dosage of radiation received	Number that will die	Deaths will occur in
5-10	2- 5 hours	10- 50R	none	N/A
50	1- 4 hours	50- 200R	less than 5%	60 + days
100	2- 4 hours	200- 400R	less than 50%	30-60 days
100	4- 6 hours	400- 600R	more than 50%	+/- a month
100	6-10 hours	600-1000R	all	+/- 2 weeks
200 plus	3 hours plus	600R plus	all	

The more intense the radiation the shorter the time before death.

1.0	1 week	150R	none	N/A
0.3	1 month	200R	none	N/A
0.1	4 months	300R	none	N/A
1.5	1 week	250R	5%	3 months
0.5	1 month	350R	5%	6 months
0.2	4 months	500R	5%	9-18 months
2.7	1 week	450R	50%	1-3 months
0.8	1 month	600R	50%	2-6 months

Example of the Effect of Shielding



Any material can be used for shielding against radiation. Even feathers. There is nothing magical about lead. It is only the density of the material that matters. A pound of lead and a pound of feathers weigh exactly the same. But it takes a much bigger stack of feathers than it does of lead to make a pound.
Neither feathers nor lead are generally particularly cheap to obtain, so it is usually better to use some other material like dirt or concrete. The more dirt or concrete in the barrier, the greater the protection. Since concrete is more dense (heavier) it only takes about 24 inches of concrete to give the same protection as 36 inches of dirt.
Thirty-six inches (three feet) of dirt will give good protection. Five feet of dirt will give better.

Nuclear Survival Groups - Table of contents

There are probably 12 nuclear survival groups in the city of Toronto. I personally know of four and I have heard of three or four others. (There may be some overlap. I can't be certain.) My guess is that there are another three or four I don't know about. Most such groups are very secretive, for various reasons. Three of the groups are headed up by instructors, like myself, who teach survival courses at the community colleges. [Author's update note: The author now maintains a listing of survival communities in North America and as of Fall 1998, had over 60 communities on the list. If you have not seen the list, you may contact the author and he will refer you to a copy].
Most of the groups contain a number of very well trained and experienced people. There are also many other groups scattered around both the US and Canada. They have their own training bases and survival courses. There is a magazine, Survive, where you can learn about some of these groups.

What is Radiological Defense Officer?

Both in the Canada and the United States the Federal Governments have trained certain individuals to be advisors to mayors and other public officials in time of nuclear disaster. In Canada these individuals are called Radiological Defense Officers.
Certain Radiological Defense Officers have received additional training, so as to become qualified to teach Radiological Defense Officers. These individuals are designated as being Radiological Scientific Officers.
The supposed requirement for becoming a Radiological Defense Officer is a Ph.D. in physics, but because of a lack of candidates, individuals with lesser qualifications have been selected.

About the Author - Table of contents

The main author of this document built twenty-three fallout shelters in Kansas and Utah in the 1960's. He completed the US Office of Civil Defense course in 1970 after moving to Canada and then the Radiological Defense Officer's course at Arnprior, Ontario in 1976, and the Radiological Scientific Officer's course in 1977.
While in the USAF, he was a control tower operator and graduated as Honor Student from the AACS supply school. Because of this training he was asked to inspect the Titan missile sites after his honorable discharge. He refused because of his understanding of what the missiles could do to mankind. He has been a member of various anti-war groups and his personal motto is "Bell the Cat and Ban the Bomb", but he thinks it is now too late to do either.
His master's degree is in Economics from Texas Christian University, and he holds certificates in both data processing and information technology, the latter from MIT. [He has also written and edited several books in the field of computer science].
Prior to becoming a college teacher of computer science he was a telephony engineer and holds both US and Canadian patents.
He presently devotes a large amount of his time to the nuclear survival group mentioned in this document.

Bibliography - Table of contents

[Author's update note: The two books that I used to most highly recommend were]:

- Life After Doomsday by *Dr. Bruce D. Clayton*; click on the title of this book to order it from Amazon.com.
- Nuclear War Survival Skills by *Cresson H. Kearny*; click on the title of this book to order it from Amazon.com.

[Author's update note: While those two books are still very valuable, and it is a good idea to read more than one author's ideas on the same subject, still there is a new book about which I am quite enthused. This book is the most recent book of which I am aware and it gives some new and updated information. From the source, presentation, and approach of the book it somewhat makes me think that its writing may have been commissioned or supported by the Mormon Church, but (which is not a negative but) whatever its source it is excellent.]
The book is "Nuclear Defense Issues",
by " Paul Seyfried and Sharon Packer of Utah Shelter Systems".
You can order in on the net from:

Utah Shelter Systems

or by mail (for $25) from:
Utah Shelter Systems
P.O. Box 638
Heber, Utah 84032-0638
U.S.A.
- -

Nuclear Weapons Effects

http://www.disastershelters.net/

Most city planners estimate that the largest weapon to be used against populations would be one megaton in size. Most references in this discussion are, therefore, made to these yields. The weapons effects of interest are electro-magnetic pulse (EMP), radiation, blast and thermal.

EMP Effect

Most experts agree that a full-scale nuclear attack would be initiated by a high altitude (approximately 200 miles high) nuclear explosion, and that it would most probably be deployed from a satellite. A nuclear bomb detonated at that altitude will not damage living tissue, will not cause significant radiation fallout and is not a health threat to the population. The purpose of this explosion is to damage critical electrical circuitry in our retaliatory defense weapons and our military communications capabilities. This is accomplished by means of the electro-magnetic pulse (EMP) associated with the explosion. One such explosion could affect an area of a thousand miles in diameter.

Collectors, such as long runs of cable, house wiring, conduit, large antennas, overhead power and telephone lines, railroad tracks, etc., gather this energy in the form of a strong current and voltage surge. All solid state electronics is vulnerable to this energy surge. The equipment does not have to be attached directly to the collector in order to be damaged. It's possible for a collector to gather in the order of a joule of energy from a one megaton, high altitude explosion. The fact that a small fraction of a joule can cause permanent damage to electronic devices, shows that the EMP threat is a serious one. The damage to equipment could include some or all of the automobile ignition systems, telephone and radio communications, airline communications, navigational aids, & computers. Our power grid throughout the United States will most probably fail. Therefore, about 95% of our radio stations will loose transmission.

If a power drop is detected, care should be taken to test telephones, radio stations, and other equipment for loss of function. Many radio stations have alternate power sources, but only about 5% of our radio stations have been hardened against the EMP. If, after checking a battery powered radio, you find that most of the radio stations are not functioning, you should take shelter immediately.

Immediately after the initial EMP explosion, SLBMs (Submarine Launched Ballistic Missiles) and ICBMs (Intercontinental Ballistic Missiles) would probably be launched against targets in the United States. An ICBM from Russia would reach the center of the continental United States in about 25 minutes. A missile from a submarine could reach us in 8 minutes. However, we are not currently seeing Russian nuclear missile submarines in our coastal waters. The 25 minutes which the power failure alarm will give you could mean the difference between life and death.

If you are asleep, a simple power-drop alarm would awaken you when the power fails. Simulations of EMP and testing of automobiles suggest a failure of the computerized ignition system could possibly be overcome by removing the battery cables, discharging them against the metal frame, waiting a few moments for the computerized systems to re-set, and then replacing the cables. It's worth a try.

RADIATION

If the fireball of the weapon touches the ground, the blast is defined as a `ground burst'. In a ground burst, rock, soil, and other material in the area will be vaporized and taken into the cloud. This debris is then uniformly fused with fission products and radioactive residues and becomes radioactive itself. It then falls to the ground as `radioactive fallout'. If the fireball from the explosion does not reach the ground, the blast is said to be an `air burst'. Radiation (except for initial radiation) does not become a factor in an air burst.

The threat of exposure to initial nuclear radiation is confined to a radius of about one and one half miles from ground zero and would prove fatal to any unsheltered individuals. However, in hardened blast and radiation shelters, people could survive all nuclear weapons effects, including initial radiation, within three quarter mile of ground zero. When constructing shelters, which may be within the initial radiation zone, careful consideration must be made to the shielding and geometry of the structure and entrances.

Gamma radiation is a great health problem for a two-week period. Everyone should stay sheltered in a good fallout shelter for two full weeks. If blast is not a consideration, 4 feet of earth cover is sufficient to shield from gamma radiation.

Alpha and Beta radiation can be stopped by a few layers of paper. However, internal to the body, they are a great health hazard. We must be careful to wash dust off of all lids before opening canned food, and wash and peel all exposed fruits and vegetables.

BLAST Effect

In the detonation of a one megaton size weapon (which is roughly equivalent to l million tons of TNT) in just a fraction of a second, the fireball grows to 440 feet. In 10 seconds, the fireball is over a mile wide. At the same time the fireball is forming and growing, a high-pressure wave develops and moves outward in all directions. This wave of air causes a huge increase in air pressure. At one-quarter mile from the crater edge, the overpressures are about 200 psi.

At 5 miles from the epicenter, the winds are 165 mph and the overpressure is aprox. 5 psi.. Most homes would be destroyed, but it is possible to survive in a basement shelter at that distance. At 6 and 7 miles from the epicenter, there will be moderate damage to residences and the likelihood of surviving in a basement is greater.

Survival in hardened blast and radiation shelters, such as the one described in NUCLEAR DEFENSE ISSUES, is possible at ground zero from an air burst; and at three-quarters of a mile from a ground burst. At that proximity, an 8-foot diameter shelter must have at least 8 feet of dirt cover over head. A 40-ft. long shelter of that diameter can house 40 people at an installed cost of approximately $250 per person. Detailed instructions for construction are given in chapter 3 of NUCLEAR DEFENSE ISSUES.

In most war fighting scenarios, the vast majority of our populations would live in areas affected by less than 5 psi. Radiation shelters should be constructed in every available basement and every person should know how to find expedient sheltering if caught away from home. Instructions for finding expedient shelters and using your basement for shelter are given in chapter 3 starting on page 131 of NUCLEAR DEFENSE ISSUES.

THERMAL Effect

Within less than a millionth of a second of the detonation, large amounts of energy in the form of invisible x-rays are absorbed within just a few feet of the atmosphere. This leads to the formation of an extremely hot and luminous mass called the fireball. If we were standing 50 miles away, this fireball would appear to us to be many more times as brilliant as the noon day sun.

You should never look directly at the fireball of a nuclear explosion. Because of the focusing action of the lens of the eye, especially at night when our pupils are open, thermal radiation can cause temporary and even permanent blindness.

The thermal pulse travels at the speed of light, (186,000 miles per second), and can last from a fraction of a second, up to several seconds. It also generally travels in straight lines, as does light. If there is no warning, you should drop and cover immediately. If you do have warning, you should take cover behind a large structure, or go to a basement or culvert. If unprotected you would receive third degree burns at 6 to 8 miles from the blast; second degree burns at a distance of 8 to 10 miles; and first degree burns at 10 to 12 miles from the blast. Burns would greatly complicate an otherwise survivable situation.

NUCLEAR DEFENSE ISSUES describes the fission and fusion process, fallout patterns, protection factors, shielding materials, and many, many other useful tools in calculating survival techniques for nuclear weapons effects. We hope this book will find a place in your emergency preparedness library online or at home.

- -

11 Steps to Survival

Canada Emergency Measures Organization

Department of National Defense
Blueprint for Survival No. 4

http://www.ki4u.com/survive/index.htm

The Eleven Steps to Survival

Governments and communities at all levels are planning for the survival of our Nation in the event of a nuclear war. But the survival of individuals also will depend upon the preparation that each person makes. Persons ready to take the right action before and following an attack will increase their chances of survival. This pamphlet describes what YOU can do before and following a nuclear attack. You can greatly increase your family's and your own protection by taking the Eleven Steps to Survival:

- Step 1: Know the effects of nuclear explosions.
- Step 2: Know the facts about radioactive fallout.
- Step 3: Know the warning signal and have a battery-powered radio.
- Step 4: Know how to take shelter.
- Step 5: Have fourteen days emergency supplies.
- Step 6: Know how to prevent and fight fires.

- Step 7: Know first aid and home nursing.
- Step 8: Know emergency cleanliness.
- Step 9: Know how to get rid of radioactive dust.
- Step 10: Know your municipal plans.
- Step 11: Have a plan for your family and yourself.

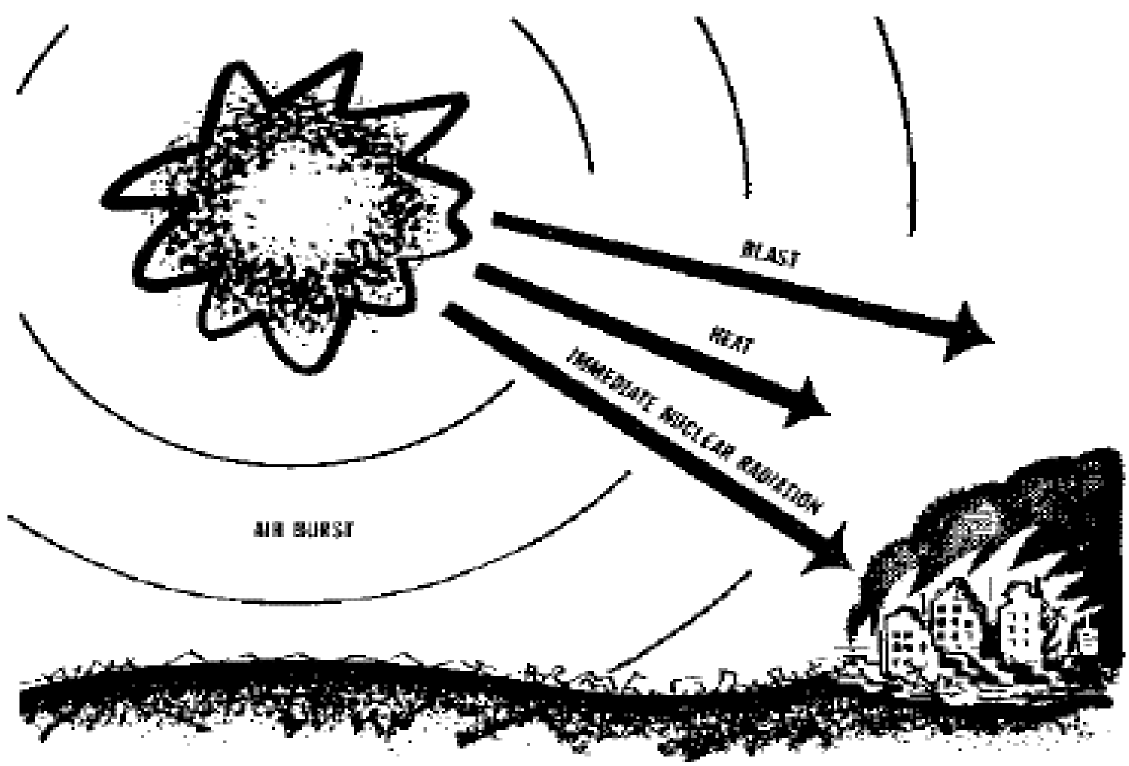
Step 1: Know the Effects of Nuclear Explosions - Back to Index

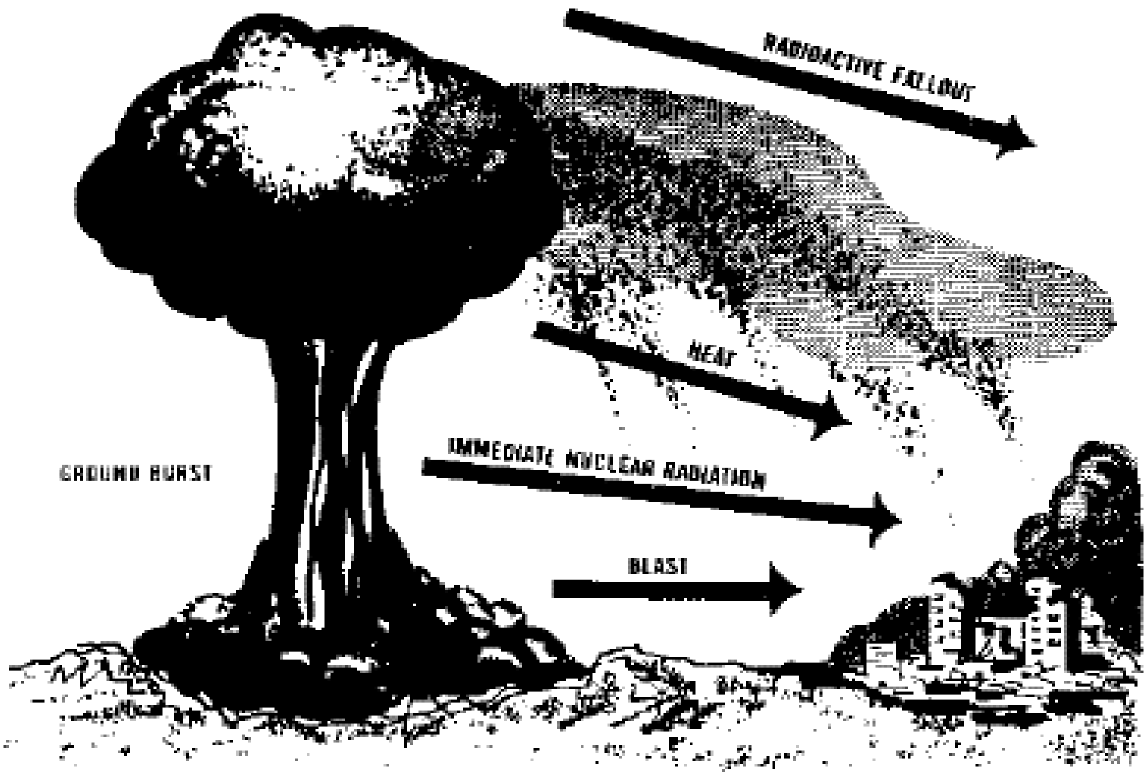
A nuclear explosion releases vast amounts of energy in three forms:

1. Light and heat
2. Blast
3. Radiation

The amount of energy released depends upon the size and design of the weapon. A wide range of weapons and delivery systems are available to an aggressor and we have no way of knowing what size of explosions might take place in Canada. For illustration purposes, we describe in this pamphlet the effects of a 5-megaton H-bomb equal to the explosive force of five million tons of TNT. Such a bomb could substantially damage the largest Canadian city.

The effects depend upon whether the weapon is exploded high in the air, or on, or near the ground. An air burst usually produces more fire and blast-damage than a ground burst which results in a big crater and more radioactive fallout. The effects described below are approximate for a 5-megaton explosion and can only be approximate since effects depend upon a number of conditions such as weather, terrain, etc.





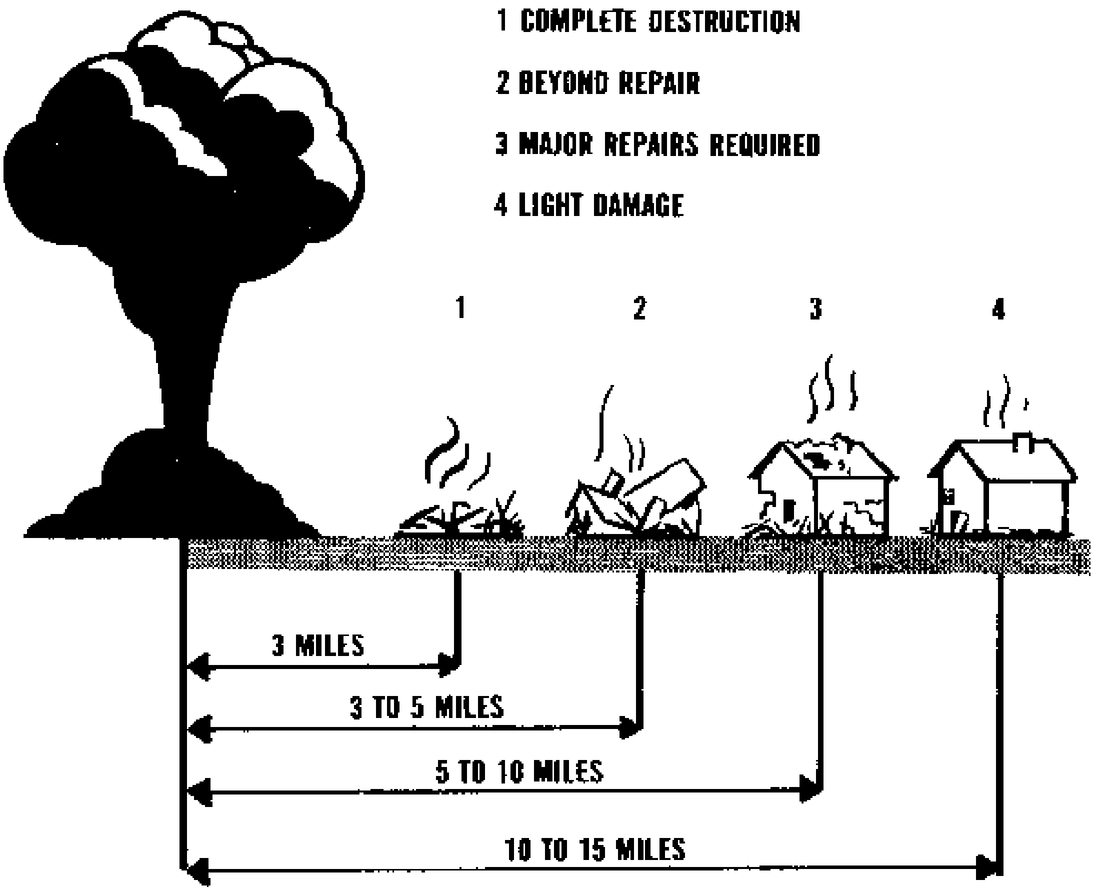
EFFECTS ON EXPOSED PEOPLE

Blast

The blast wave travels more slowly than the heat flash. Several seconds may pass after you have seen the light or felt the heat before the blast wave reaches you, depending on the distance you are from the explosion.

It is like the time between seeing the flash of lightning and hearing the sound of thunder. For example, at ten miles from the center of an explosion, it would take about 35 seconds for the blast wave to reach you. If caught in the open during a nuclear explosion, this time can be used to find some protection from the blast wave.

You might be injured by being thrown about by the blast; therefore, keep low. The greatest danger is from flying glass, bricks and other debris. The blast from a 5-megaton explosion could injure people as far away as 15 miles.



The kinds of damage that the blast can do to buildings are:

· Complete destruction of all buildings three miles from the center of the explosion.

· Damage beyond repair to buildings three to five miles distant. They would have to be torn down.

· Major repairs required to buildings five to 10 miles distant before they could be occupied.

· Light to moderate damage to buildings 10 to 15 miles distant. They could be occupied during repairs.

A 20-megaton bomb increases the approximate ranges of damage described above to five, eight, sixteen and twenty-four miles.

These are approximate distances as the strength of buildings is not uniform. For example, reinforced concrete buildings are more blast resistant than wood frame structures. In some areas four miles away from the explosion, concrete buildings might be repairable, while wood frame buildings would be completely destroyed. Windows, of course, are very vulnerable and are apt to be blown in as far away as 25 miles from the explosion.

Radiation

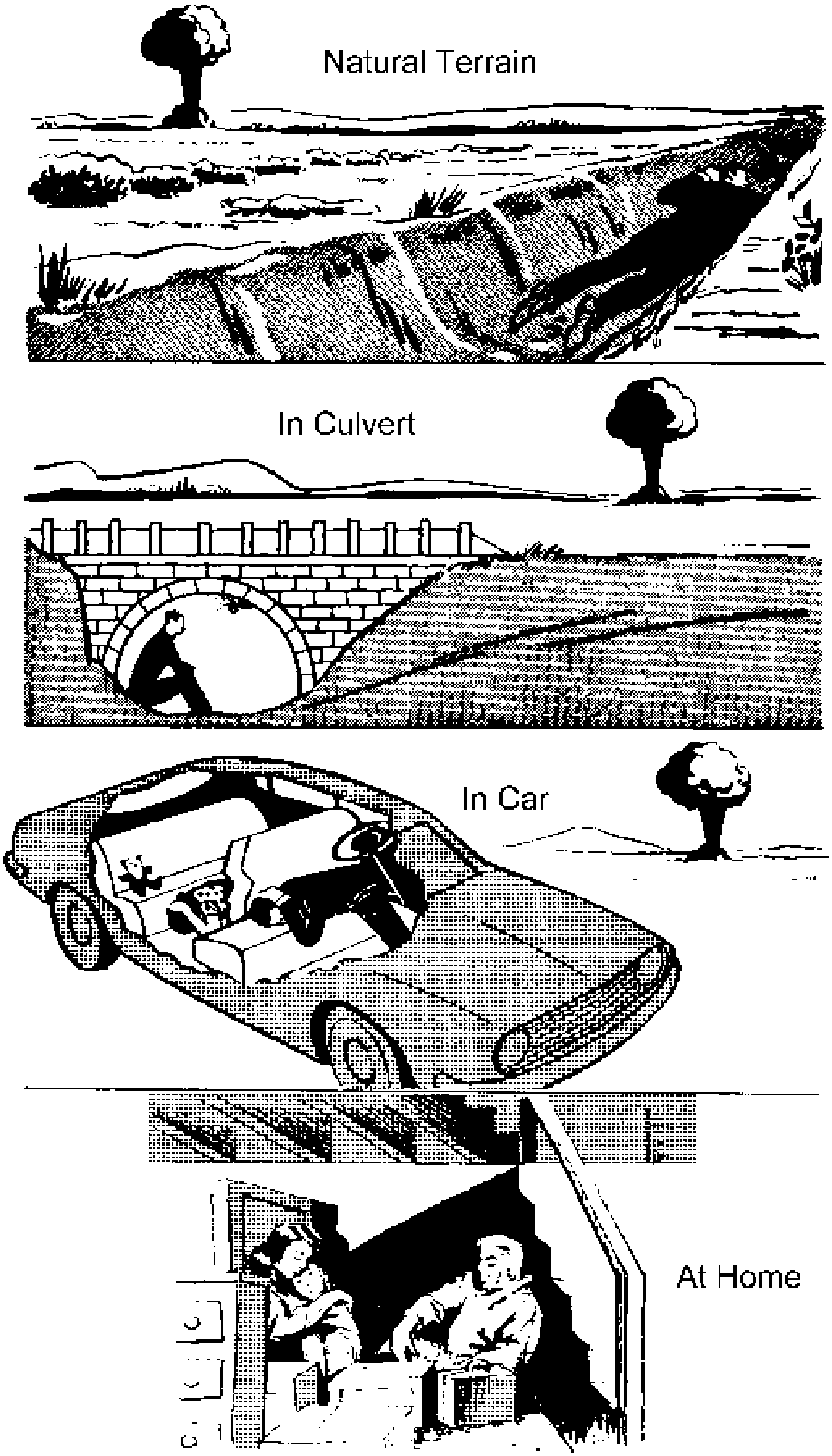
A nuclear explosion causes both immediate radiation and residual radiation.

Immediate radiation is given off at the time of the explosion. It is dangerous only within two or three miles. If you were near the explosion without adequate protection and managed to survive the effects of blast and fire, you could still be seriously affected by immediate radiation.

Residual radiation is given off by the radioactive particles left as "fallout" after the explosion. The danger from fallout would be so great and widespread that it is discussed separately, in Step 2.

Protection against Heat, Blast and Immediate Radiation

The illustrations below show some of the most probable situations in which you might find yourself at the time of a nuclear attack, and what you should do:


Natural Terrain
In Culvert
In Car
At Home

Step 2: Know the Facts About Radioactive Fallout - Back to Index

If a nuclear weapon is exploded on, or near, the ground, danger from radioactive fallout is greatest. The force of the explosion may make a crater up to a mile wide and to a depth of one hundred feet. Millions of tons of pulverized earth, stones, buildings and other materials are drawn up into the fireball and become radioactive. Some of the heavier particles spill out around the point of explosion. The rest are sucked up into the mushroom cloud.

This radioactive material is then carried by winds until it settles to earth. This is called "Fallout". Under some circumstances you may see the fallout; under others you may not.

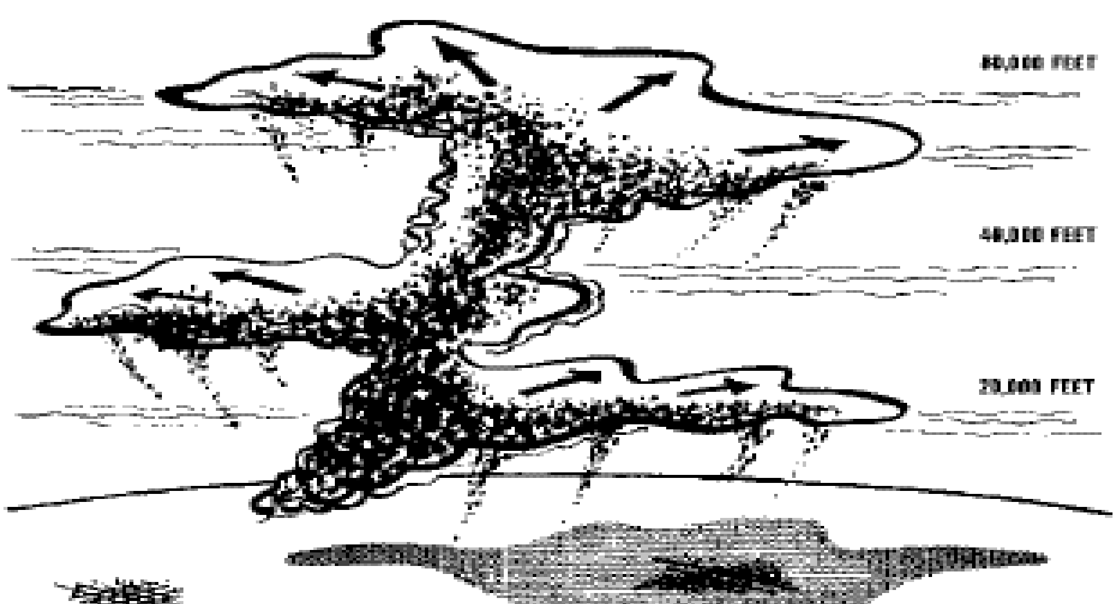
The radioactivity it gives off cannot be seen. You can't feel it. You can't smell it.
But fallout doesn't come out of the sky like a gas and seep into everything. It can best be described as a fine to coarse sand carried by the winds. Because the wind direction varies at different heights above the ground, it is not possible to judge from the ground where the fallout will settle. It can settle in irregular patterns hundreds of miles from the explosion.

The fallout from a 5-megaton explosion could affect seriously an area of 7,000 square miles. If nothing were done to gain protection during the period of high radioactivity, there would be a grave danger to life in that area.

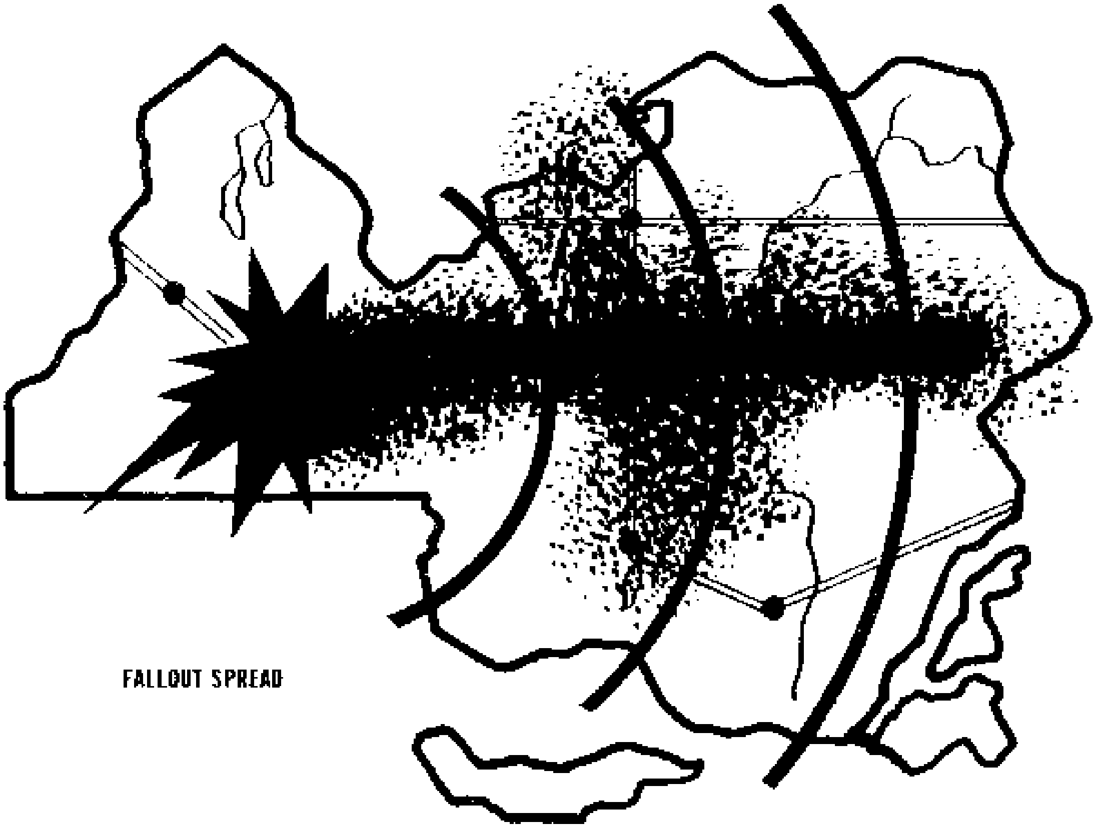
Because fallout is carried so far and covers such a large area, it could be the greatest danger to the largest number of Canadians in a nuclear war. If Canada was not hit by nuclear bombs, those exploding in the United States close to our border could result in serious fallout in many parts of Canada.

There are four things which determine the amount of radiation reaching your body from fallout:

1. The time that has passed since the explosion.
2. The length of time you are exposed to fallout.
3. The distance you are from the fallout.
4. The shielding between you and the fallout.



DIRECTION OF FALLOUT AT VARIOUS ALTITUDES

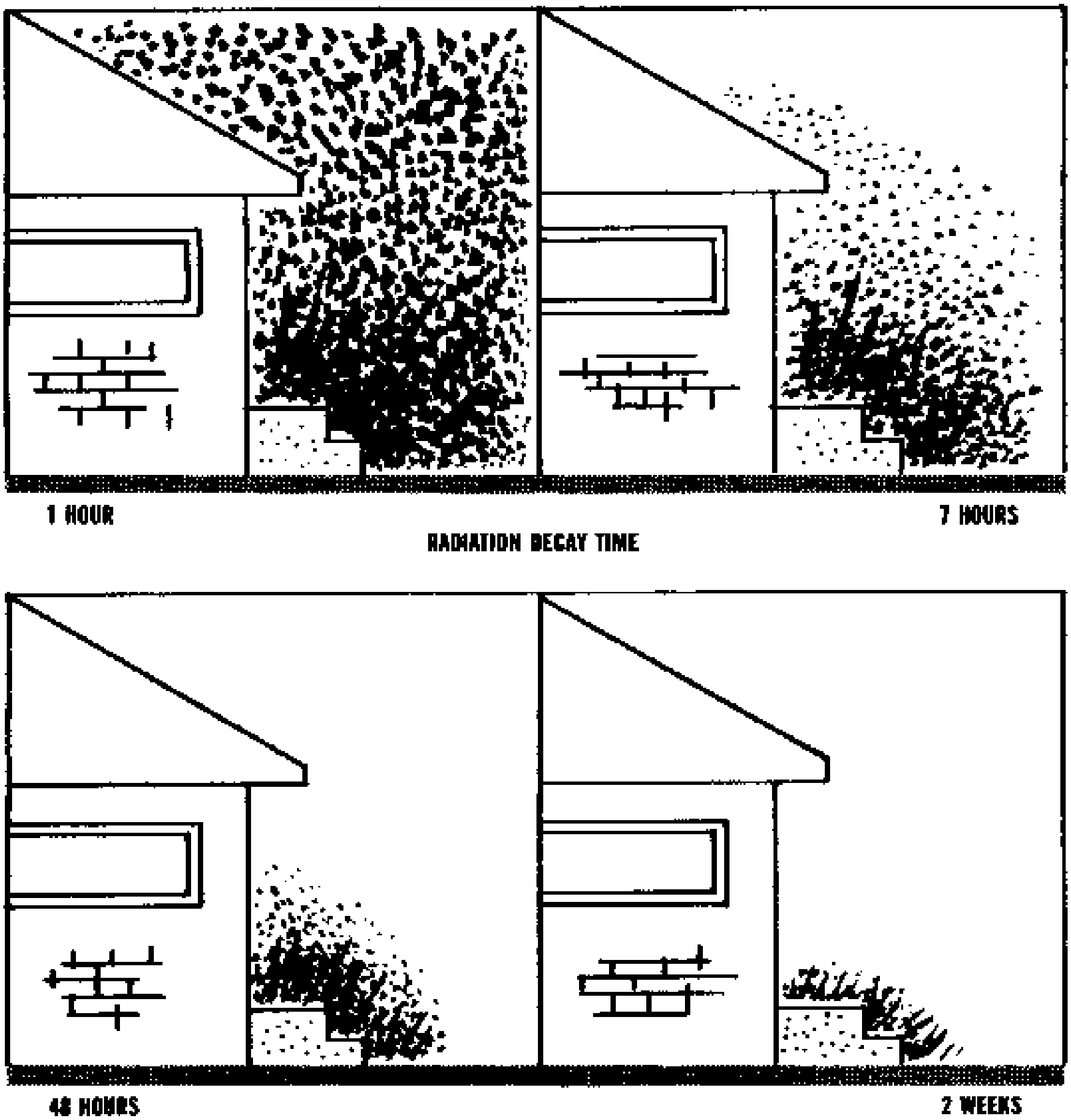


FALLOUT SPREAD

Time

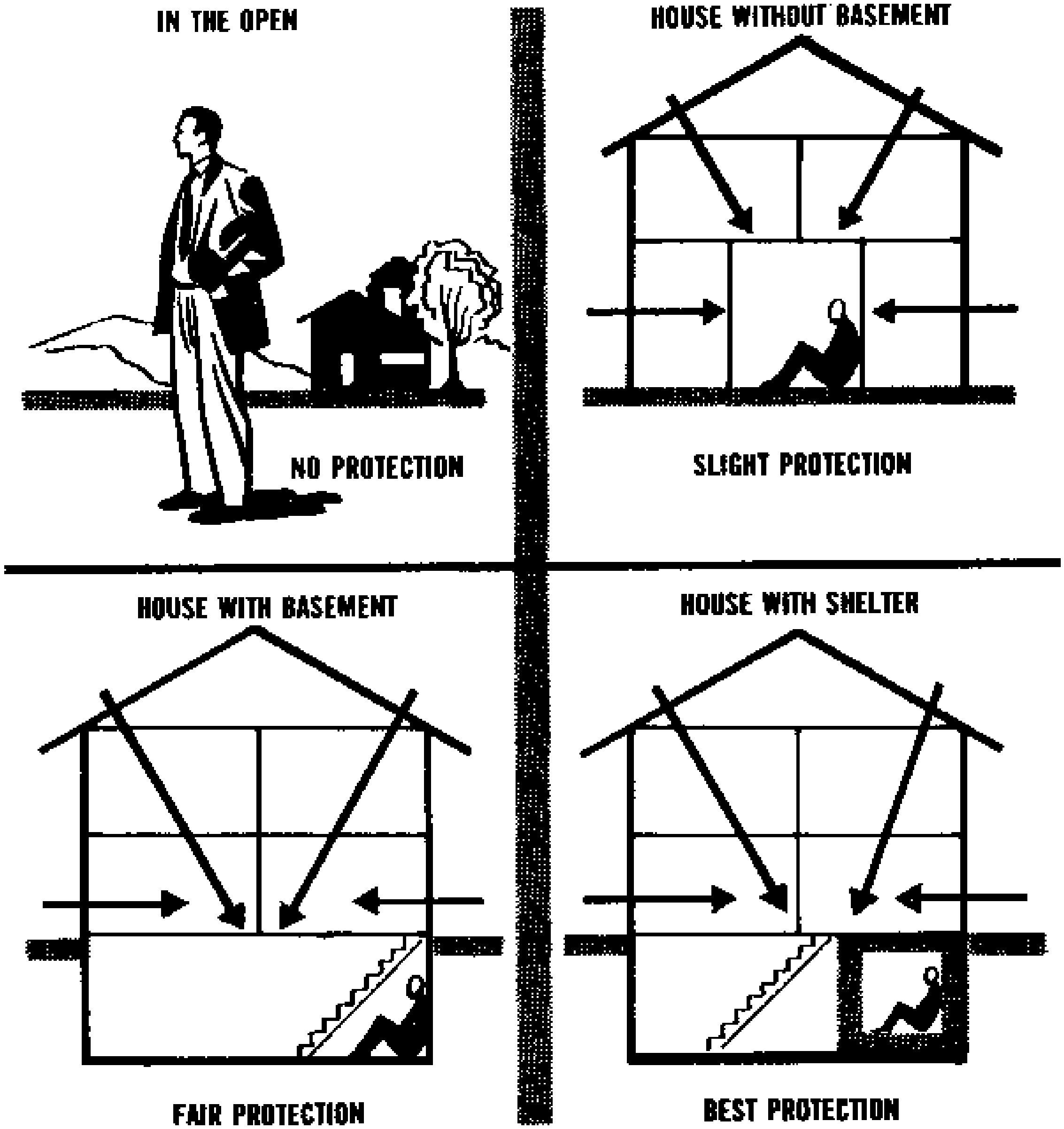
The radioactivity in fallout weakens rapidly in the first hours after an explosion. This weakening is called "decay". After seven hours, fallout has lost about 90% of the strength it had one hour after the explosion. After two days it has lost 99%; in two weeks 99.9% of its strength is gone. Nevertheless, if the radiation at the beginning were high enough, the remaining 0.1% could be dangerous.

Radiation must be measured by special instruments handled by people trained to use them. But, if you stay in a shelter during the first days following an explosion, you escape the strongest radiation. *You should stay in the shelter until radiation has been measured and you have been told aver the radio that it is safe to come out.*



Distance

The strength of radiation reaching your body is reduced the farther you are from the fallout. Here are some illustrations of the safest place to be when you are in various kinds of buildings.



Shielding

The most effective protection is to place some heavy material between yourself and the fallout. The heavier the material the better the protection. Many common materials give excellent protection. The materials and design of the fallout shelter recommended in **Blueprint for Survival No. 1** will stop penetration of 99% of outside radiation.

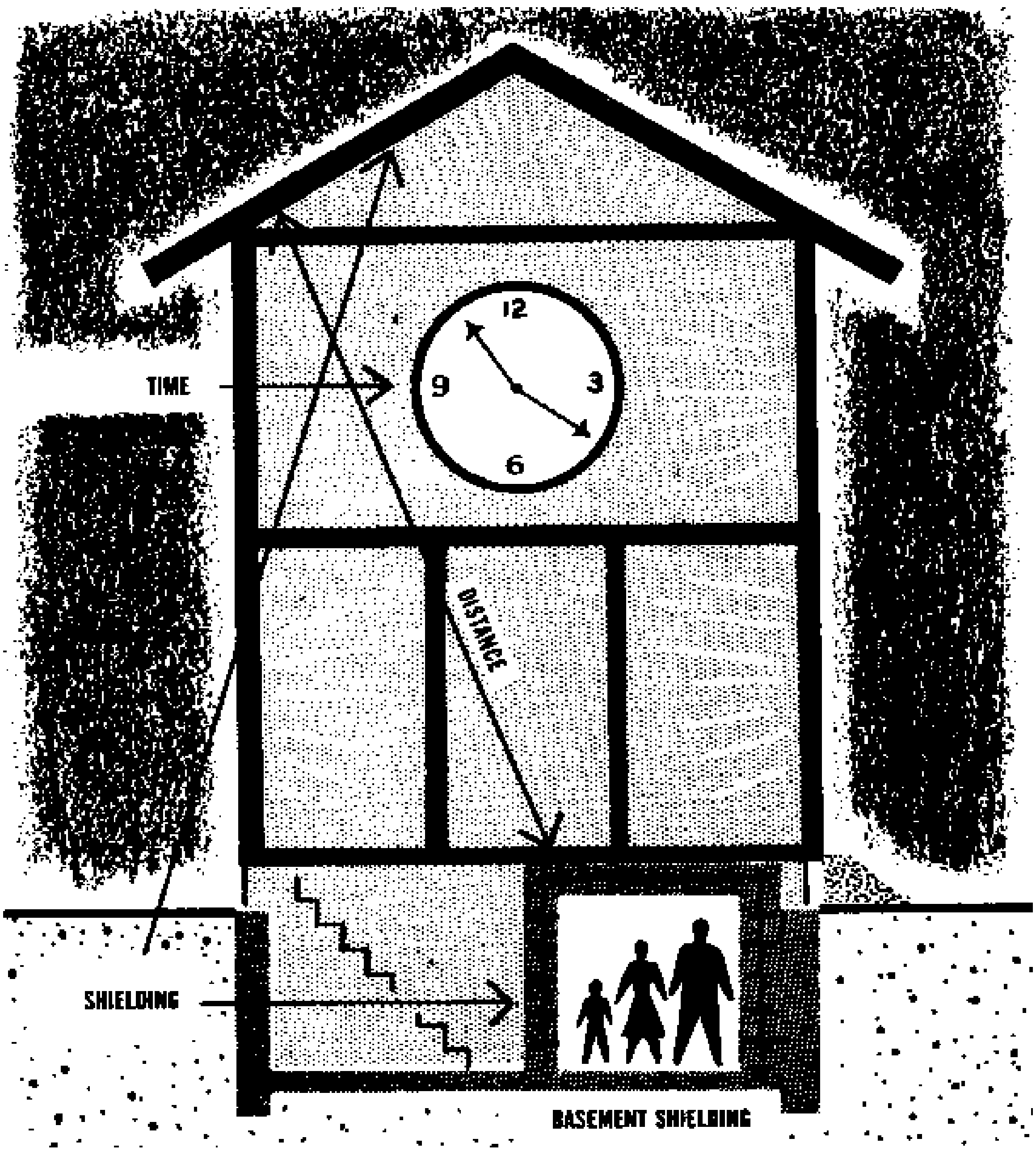
These thickness' of material will stop 99% of radiation:

- 16 inches of solid brick
- 16 inches of hollow concrete blocks filled with mortar or sand
- 2 feet of packed earth Ä 3 feet if loose
- 5 inches of steel
- 3 inches of lead
- 3 feet of water

A fallout shelter is the best way to protect your family and yourself against radiation because:

- It keeps the radiation at a distance.
- It shields you from radiation.
- The time spent there is the period when radiation is most intense.

By providing your family and yourself with a fallout shelter, you are unlikely to suffer serious effects from radioactive fallout.



Personal Danger from Fallout

Radioactive particles in contact with your skin for a few hours may produce burns. Follow Step 9 to prevent this danger.
Radioactive particles swallowed in food or water might be harmful. Follow Step 9 to prevent this danger.
Radioactivity from an area of fallout may produce illness in the unprotected individual after a few days. Follow Step 4 to prevent this danger.
Radiation illness develops slowly. It cannot be spread to other people. Except for temporary nausea shortly after exposure, evidence of serious effects from radiation may only appear after an interval of from a few days to three weeks. A combination of loss of hair, loss of appetite, increasing paleness, weakness, diarrhea, sore throat, bleeding gums and easy bruising indicate that the individual requires medical attention. *Nausea and vomiting may be caused by fright, worry, food poisoning, pregnancy and other common conditions.*

Step 3: Know the Warning Signal and have a Battery-Powered Radio -

Back to Index

All Canadian communities where there is a likely need are provided, or will be provided, with sirens. Other areas should have warning arrangements based on local systems such as telephones, horns, bells or factory whistles.
Warning devices are only attention-getters. Dependent on the size of your municipality, the sirens, bells, telephones, etc., will sound the Attack Warning.
There is one type of siren warning signal in Canada:

The ATTACK WARNING Signal

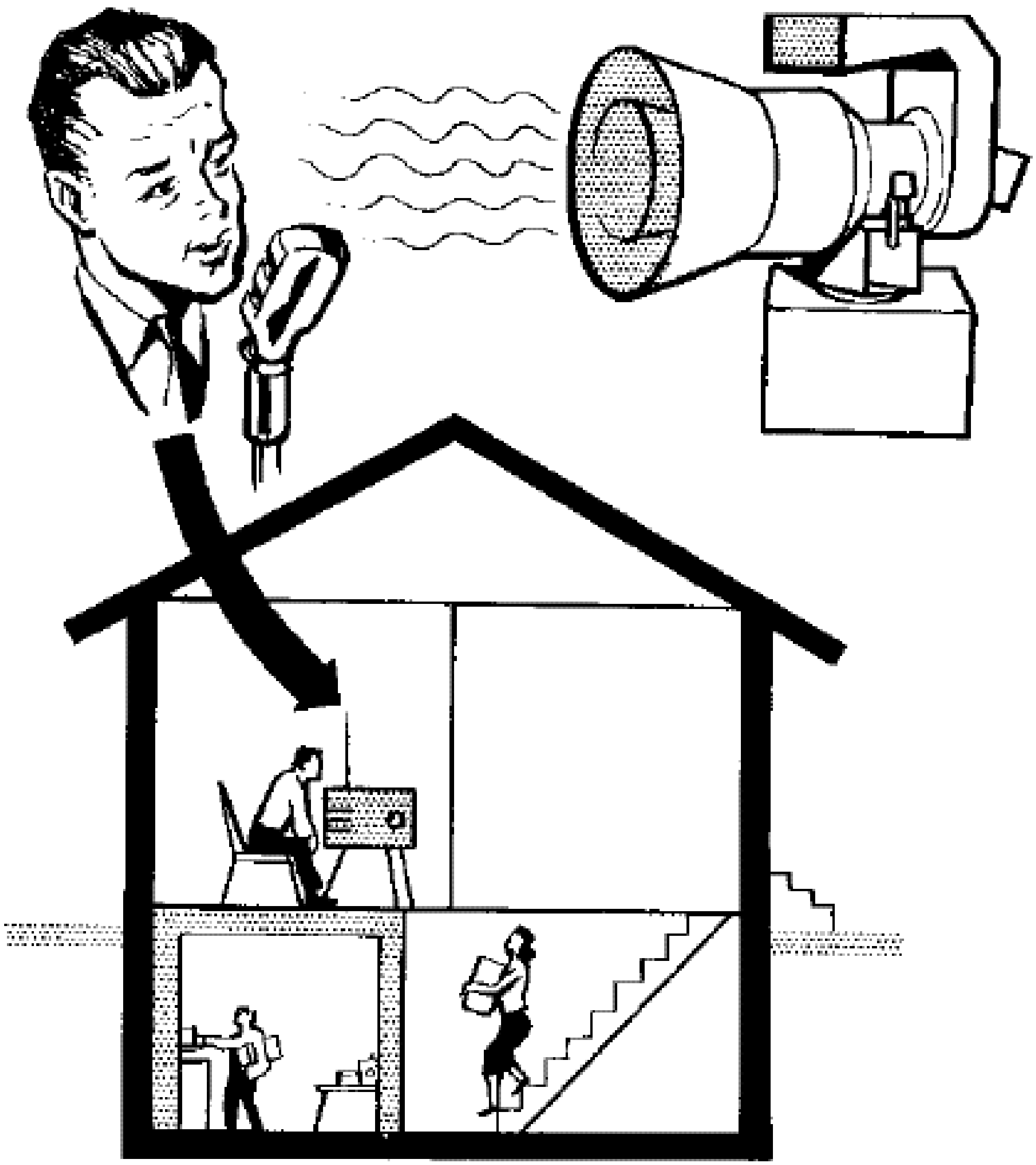
The ATTACK WARNING Signal: A wailing (undulating) tone on the sirens of three to five minutes duration or short blasts on horns or other devices repeated as necessary means:

- An attack on North America has been detected;
- Warning of fallout.

WHEN YOU HEAR THE WARNING SIGNAL, YOU SHOULD TAKE PROTECTIVE ACTION AND LISTEN TO THE RADIO FOR INSTRUCTIONS.

A Radio is Essential

When the Attack Warning sounds, you must take protective action. Take a battery-powered radio with you. Broadcast advice and instruction may help to save your life. If you don't have a portable radio, turn up the volume of your house radio so that it can be heard in your shelter. If away from home you are forced to take emergency shelter and are near a radio-equipped vehicle, turn up the volume and open all the vehicle's doors or windows.
The Canadian Emergency Broadcasting System, a network of all Canadian radio and television stations which will be formed when a nuclear attack on Canada has been detected, will tell you when and how to take emergency protective action against possible attack and shelter against fallout if an attack occurs.



Before Attack

If sirens or warning systems signal impending attack, regardless of where you are or what you are doing, you must take the best available cover against the blast, heat and light effects of nuclear explosions.

Emergency broadcast instructions will include the following advice:

- If you are at home go to the basement or strongest part of your house or building which offers the best protection. If material is handy, improvise blast protection. See Step 4.
- Take your battery radio with you, or turn up the house radio so that you can hear it while under cover.
- Stay away from windows.
- Lie down and protect yourself from flying glass and falling debris.
- Shield your eyes from the flash of an explosion.
- If you are away from home take protective cover immediately.
- If you are travelling, stop and take protective cover immediately, or if you are only a few minutes from a safe destination, proceed and take protective cover immediately.
- Listen to your radio for further instructions.

After Attack

If sirens or warning systems sound following nuclear attacks, the warning may mean another attack or that radioactive fallout is approaching your area. **You will be advised over the radio.** If the advice concerns fallout, you must take cover against the fallout effects. (See Step 4).
Radio broadcasts will identify areas which will be affected by the fallout and give instructions and advice. These might include:

- Location of nuclear explosions causing local fallout.
- Information about the parts of the country to be affected by fallout.
- Length of time before fallout is likely to reach specific communities or areas.
- Ways to increase fallout protection.
- Supplies to take to your fallout shelter.
- Whether it is safer to stay in your community or area, or to go to other areas.
- Advice as to which areas are free of danger.
- Advice on when to leave shelters and for how long as danger from radioactive contamination diminishes.
- Requests for help in rescue operations, such as rescue, firefighting and medical assistance.
- Advice on conservation of food, water and fuel.
- How to keep warm when power is off and the weather is cold.

Don't Use The Telephone

When the sirens sound don't use the telephone. Listen to a radio or television for information. In the event of an Attack Warning telephone lines will be required for official use.

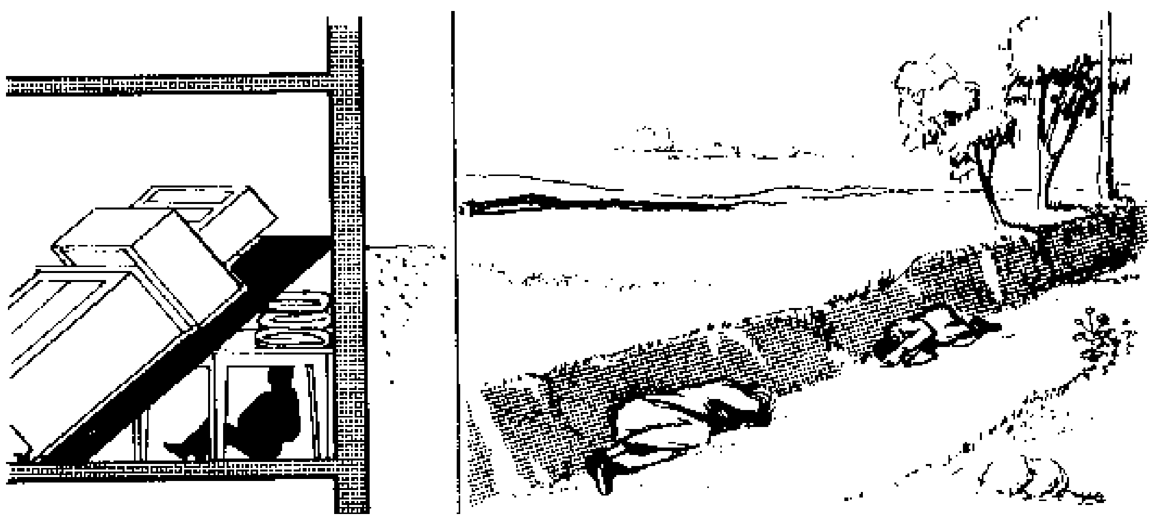
Step 4: Know How to Take Shelter - Back to Index

It is important to provide your family and yourself with a shelter. But what kind of shelter? This is a decision you must make yourself after studying the problem.
Study your shelter requirements in the same way that you would study accident or fire insurance. Decide upon the degree of protection you want for your family and yourself. Shelter is your insurance against something you hope will not happen, but if it does, will give you protection.
Shelters of the type commonly used in Europe during the Second World War would not provide protection against the blast of a nuclear explosion. They were designed to withstand short shock pressures lasting something like 1/100th of a second. Shelters designed to withstand the pressures

created by a nuclear explosion must be able to stand up to pressures lasting as long as 6 seconds. In addition, they must be capable of giving the occupants protection against fires outside the shelter as well as against radiation.
The fallout shelter is designed to give protection against radioactive fallout only. Because most people in Canada probably would not be affected by the blast and heat effects of nuclear explosions, protection against fallout is all that is required by them.
The type of shelter for good protection depends upon the distance it will be from the explosion. Unfortunately, it is not possible to know this in advance. That is why each individual must make his own decision when selecting the type of shelter he wishes to have.
Blueprint for Survival No. 1 gives details of a fallout shelter for the home in which you now live. If you rent the home, the decision to construct a shelter must be taken jointly with your landlord.
Blueprint for Survival No. 2 gives details of a fallout shelter for the new home you may be planning to build.
Blueprint for Survival No. 6 gives details of blast shelters which may be built outside the home. These pamphlets are available from your local Emergency Measures or Civil Defense Organization.

Improvised Protection Against Blast

One of the simplest ways to improvise some anti-blast protection is to build a lean-to (bed springs or boards) against a work bench or heavy table, preferably in the basement, and pile mattresses on it and at the ends. If the material is readily available it could be built in a matter of minutes after the ATTACK WARNING is sounded and could protect you from loose bricks, flying glass, etc.
If you are in the open and there is a ditch or culvert within easy, quick reach, lie face down in it and cover your face with your arms. Make sure this shelter is not too close to buildings which could collapse into it.

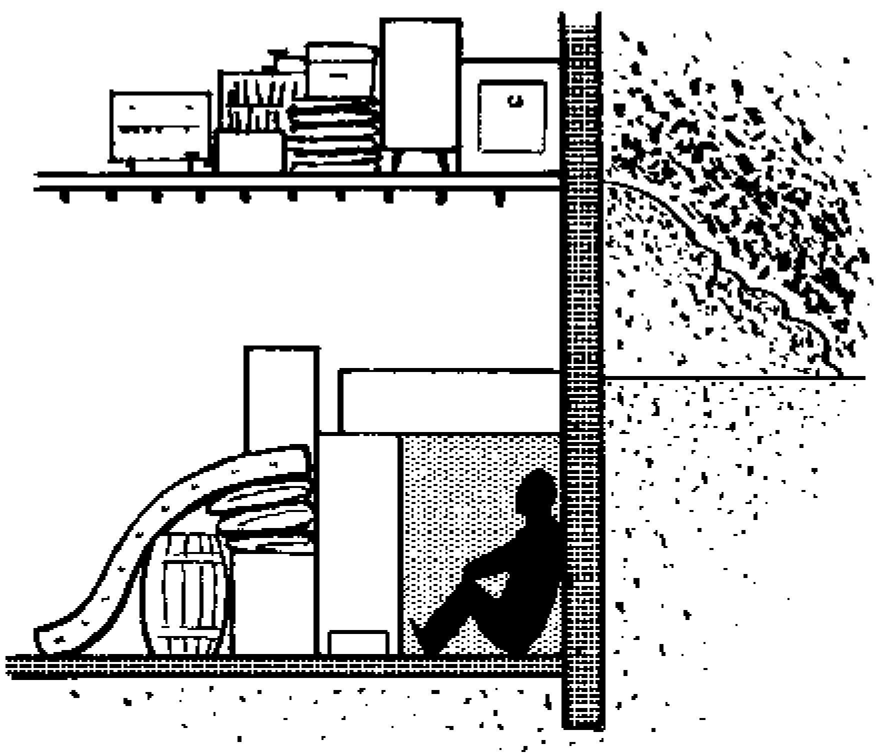


"After" the blast and heat of the explosion, you would have to find other protection against fallout which will come down later. (Don't forget your battery-powered radio).
None of these improvisations is as good as a properly equipped blast shelter, but any single one of them could mean the difference between life and death.

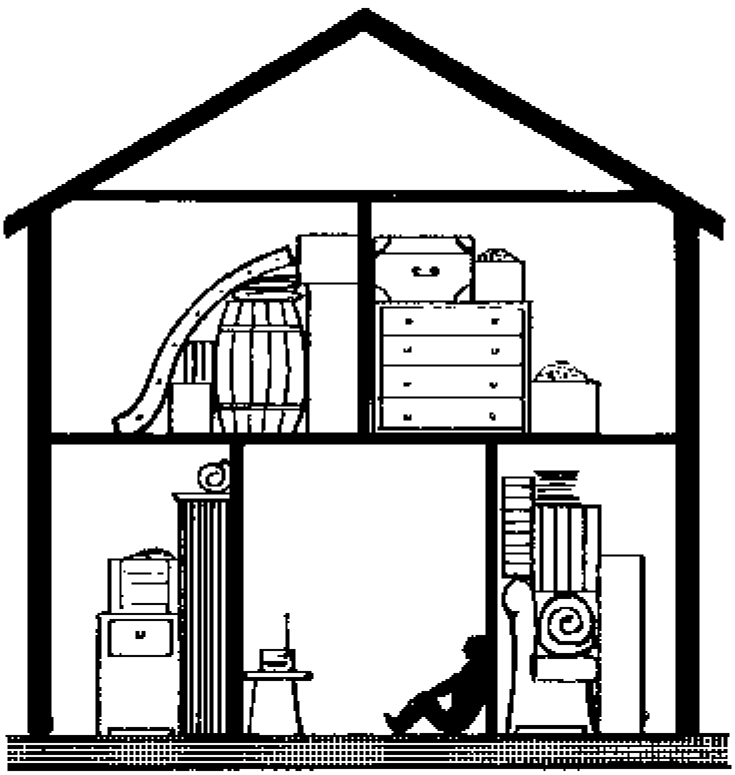
Improvised Protection Against Fallout

You may not have a fallout shelter when warning of approaching fallout is broadcast. Here are some tips on how to increase your protection in a basement. The amount of protection you can build will depend on how much time you have available until fallout arrives.

- You can improvise a small emergency shelter by using furniture, doors, dressers, work-bench and other materials.
- Select a corner of your basement, if possible away from windows, in which to build your shelter. Remove inside house doors from hinges to use as a shelter roof over supports. Supports for the improvised roof can be cabinets, chests of drawers, work-bench, or anything which will bear a heavy load. Use the house doors as a roof surface to provide a base for the heavy material you will have to place on it. Bricks, concrete blocks, sand-filled drawers or boxes, books or other dense items on the roof will help reduce radiation penetration. Around the sides and front of your shelter build walls of dense materials to provide vertical shielding. A small cabinet or dirt-filled box as may be used as a crawl-in entrance which can be closed behind you.
- Remember, the heavier or more dense the material around you, the greater the protection.
- Block basement windows with earth, bricks, concrete blocks, books or even bundles of newspaper. In winter, use packed snow.
- On the floor above the corner of the you select as your shelter area, pile any heavy objects you may have available, such as furniture, trunks filled with clothes, dirt-filled boxes, books, newspapers, or earth from outside.
- Outside, against above ground walls of the basement around your shelter area heap earth, sand, bricks, concrete blocks or packed snow.



If your home has no basement or crawl space, build your emergency shelter in that part of the house (center hall or clothes closet) farthest away from outside walls and the roof. Build it as described for houses with basements. On the floor immediately above your shelter area, and against surrounding walls, pile up furniture, trunks, dressers, dirt filled boxes or other heavy material, which will reduce radioactive penetration into your emergency shelter.



Step 5: Have 14 Days Emergency Supplies - Back to Index

Nuclear attacks on centers of production, and fallout conditions, may curtail the distribution of available food stocks for several days or even weeks following these attacks. Persons who had taken shelter against fallout might be advised to stay in their shelters for as long as 14 days. Those who had chosen to evacuate larger cities would be dependent largely on the resources available in reception towns. Because of these possibilities, it is recommended that every person should have emergency supplies. These supplies should include food, water, battery-powered radio, first aid kit, and where necessary, medical supplies as recommended in Step 7. Heavy clothing would be necessary in winter. Extra changes of clothing should be considered particularly stockings and underclothing.

For those who may choose to evacuate major centers, supplies must be selected carefully because of space limitation in the family car. Supplies should be packaged beforehand so that they can quickly be put into the car. See the pamphlet "Your Emergency Pack" available from your local Emergency Measures or Civil Defense Organization.

Many of the recommended items are already in your home.

Whether you choose to evacuate or take shelter locally, you should have a road map with you. You could then relate the information about areas under fallout, which you would hear about on the radio, to your actual location. Toys, games, books for your children would help to occupy their time if they had to remain in shelter from fallout. Your battery-powered radio will keep you in contact with the outside world.
The following is a suggested list of items from which your two weeks' supplies should be developed to be in your shelter or handy to it.

Equipment

- Beds (bunks or folding)
- Bedding
- Toilet
- Polyethylene bags for toilet
- Table (folding or other)
- Stools (folding)
- Cups and plates (disposable)
- Knives, forks, spoons
- Can opener
- Cooking utensils
- Kerosene cooker *(Do **not** use a pressurized stove in the confines of your shelter.)*
- Kerosene lamp
- Kerosene (sufficient for 14 days)
- Candles
- Safety matches
- Hand basin
- Calendar
- Paper towels
- Garbage can (two if no waste water runoff is possible)
- Garbage bags
- Shovel
- Broom
- Battery radio and spare batteries
- Electric lamp and spare bulbs
- Clock
- Flashlight and spare batteries
- Fire extinguisher
- Hand tools
- Pocket knife
- Axe
- String
- Light rope

Recreational

- Books
- Paper
- Pencils
- Playing cards
- Chess, checkers, other games
- Crosswords, other puzzles
- Knitting, sewing, etc.
- Hobby materials

- Plasticine

Toiletries

- Soap
- Toothpaste
- Toothbrushes
- Detergent
- Nail brush
- Razor, blades and soap
- Women's basic cosmetics
- Tissues (face and toilet)
- Face cloth
- Towels
- Brush and comb

Clothing and Personal Items

Coveralls, rubber boots, rubber gloves for adults. To be used in venturing outside even after instructions have been given that this is safe for short periods.

- Bedding (blankets preferable)
- Warm sweaters and socks
- Change of underclothing and socks
- Personal hygiene items for women
- Baby clothes
- Baby feeding equipment
- Disposable diapers (two-week supply)
- Legal papers
- Plastic sheeting

Medical - **(See Step 7)**

Food

These are suggested items and amounts for each adult for 14 days in shelter. Check off the items as you stock them in the shelter and mark the purchase date on them. Food stored for emergency use should be used and replaced at least once a year.

- Milk: 14 cans (6-oz) or 6 cans (15-oz) evaporated milk or 1-lb dried skim milk
- Vegetables: 6 cans (15 or 20-oz) - beans, peas, tomatoes, corn
- Fruits: 6 cans (15 or 20-oz) Ä peaches, pears, apple sauce
- Juices: 6 cans (20-oz) Ä apple, grapefruit, lemon, orange and tomato
- Cereals: 14 individual packages (sealed in wax bags inside or outside)
- Biscuits:
    - 2 packages of crackers (1-lb. each)
    - 2 packages of cookies or graham wafers
- Main Dish Items:
    - 2 cans meat (12-oz) - corned beef, luncheon meats
    - 2 cans beef and gravy
    - 2 cans baked beans (15 or 20-oz)
    - 2 jars cheese
    - 2 cans fish (8-oz)
- Canned and Dehydrated Soups: 2 cans (10-oz) - bean, pea, tomato, vegetable

Other Foods:

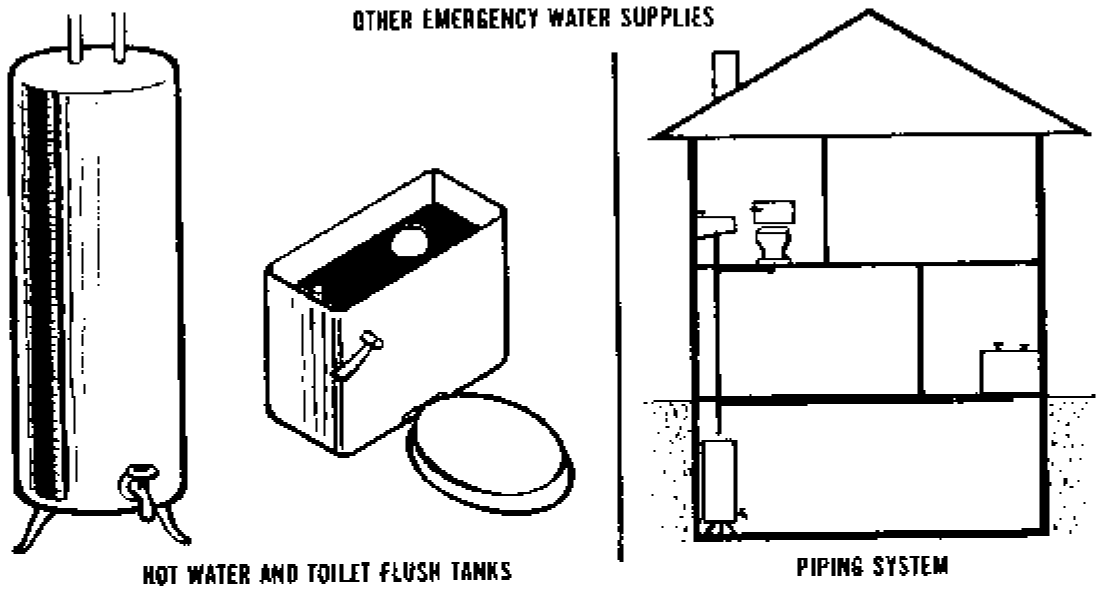
- 1 large jar or can honey, syrup, jam or marmalade
- 2 lbs. hard candy
- 1 jar or can peanut butter
- 1 package tea bags or instant tea
- 1 jar sugar
- 1 jar instant coffee
- Salt and pepper
- Instant chocolate powder
- Chewing gum

Special Requirements for Children

- For each infant include 14 cans evaporated milk (15 oz) and infant food for 14 days.
- For each child up to 3 years, include 8 extra cans of milk.
- Decrease amounts of other foods according to appetite.
- Food for older children can be the same as for adults; adjust amounts according to appetite.

Water

- Requirements: 14 gallons for each adult member of family; more for younger children (some water may be replaced by canned beverages).
- Containers: Store in well-cleaned, covered containers such as large thermos jugs, new fuel cans, large bottles, or plastic containers.
- Change: Change stored water at least once a year.



Step 6: Know How To Prevent And Fight Fires - Back to Index

Misinformation about the fire danger from nuclear explosions is widespread and common. For example, some persons believe that the fireball would completely incinerate a city. This is not true.

The heat from the fire-ball lasts about 15 seconds and would create fires which are no different from the fires you see in peacetime. They can be put out with water and extinguishers, and if each survivor were able to put out a small fire quickly, mass fires would not take place.

The heat flash from the fireball entering through windows and doors could set fire to curtains, clothes, furniture and paper. Other fires could break out in attics, in backyard trash, on wooden shingles and on the outside of houses built of wood particularly if they are unpainted or weathered.

Knowing how to prevent and fight fires at home and at work reduces the number of peacetime fires. The same knowledge will also reduce the number of fires caused by a nuclear explosion.

But how can you fight fires in the presence of fallout? From 5 to 15 miles from the center of the explosion, there will be many survivors. Fallout will not start coming down for about 30 minutes. During this half-hour, survivors should inspect their houses and put out all the small fires they can. They must not rely on the fire department to extinguish these fires.

You should have in your home and place of work, fire extinguishers, or in an emergency, create a water supply for fire fighting in pails, bathtubs, washtubs, etc. Don't rely on being able to use the established water supply system.

Even those who live in areas not attacked may find their fire departments will have to fight major fires elsewhere. Every householder should learn how to carry out fire prevention and know how to fight small fires. It may prove of value in peacetime!

Your local fire authorities are always anxious to advise you on how to fight fires. Attend any emergency fire fighting classes held in your area.

Here are some tips for an emergency:

- Prepare for emergency by preventing accumulations of trash and rubbish in and around the home. This would include dry leaves and grass, lumber, boxes, cardboard cartons, old unused furniture, bales of newspapers, etc. Keep waste and garbage in covered containers.
- The shaking and twisting of buildings and homes due to blast waves in wartime or earthquakes and explosions in peacetime, may break utility inlets at the point they enter the structure. This may allow gas or fuel oil to flow into basements creating a severe hazard. Do not smoke, strike a match, or a lighter, to light your way into a darkened basement. Gas or oil vapors may be present and a violent explosion and fire may result.
- To lessen the danger of fires and explosions follow local instructions about shutting off utility services when the ATTACK WARNING sounds.
- If you have a coal-burning furnace, or a wood-stove, extinguish it or at least be sure to close all fuel and draft doors.
- Close curtains, shutters or venetian blinds on all windows and remove furniture from window areas.

TO FIGHT AN ORDINARY FIRE:

- **Take away its fuel.** Get the burning material out of your home.
- **Take away its air.** Smother it with a blanket, wet if possible, or a rug.
- **Cool it** with water, earth, sand or a fire extinguisher.

GAS, OIL, ELECTRICAL FIRES REQUIRE SPECIAL METHODS:

- **Gas fire:** Make sure the gas is shut off and then try to extinguish anything still burning.
- **Oil fires:** Make sure the supply is shut off then smother the fire with earth, sand, rugs or other heavy materials. Don't use water.
- **Electrical fires:** Make sure the electricity is shut off, then put out the fire. Don't use water if the power is still on.

PROMPT ACTION TO PUT OUT SMALL FIRES IMMEDIATELY FOLLOWING A NUCLEAR ATTACK WILL SAVE LIVES!

Step 7: Know First Aid and Home Nursing - Back to Index

The acquisition of First Aid and Home Nursing skills prepares individuals to serve effectively in a national emergency. If such an emergency occurs, the care of many thousands of injured or seriously ill persons becomes a tremendous task for the organized health services. Doctors and nurses may not be readily available to assist you. Thus the importance of First Aid and Home Nursing skills takes on a new dimension. The survival of the injured or sick members of your family may become your responsibility.

The main objectives of training individuals in first aid and home nursing are:

1. To preserve life
2. To minimize the effects of injury or illness
3. To relieve suffering or distress
4. To provide continuing care and assist in rehabilitation.

Therefore you must:

- Know and practice life-saving first aid.
- Know and practice simple home nursing measures.

First Aid Supplies

A simple first aid box kept in your shelter or in your evacuation kit should contain:

- 1 bottle mild antiseptic solution (use to clean cuts)
- 5 yards 2-inch gauze bandage
- 2 triangular bandages (use for slings)
- 12 4" x 4" sterile pads (use to cover cuts, wounds and burns)
- 12 assorted individual adhesive dressings (use for minor cuts)
- 2 large dressing pads (shell dressing type) 8" x 8" (Available at minimal cost from St. John Ambulance Association)
- 5 yards 1/2 inch adhesive tape
- 9 assorted safety pins
- 1 small bottle toothache drops (for temporary treatment of toothache)
- 1 tube of petroleum jelly
- 1 small bottle aspirin tablets
- 1 thermometer
- 1 small scissors (blunt ended)
- 1 medicine glass
- 1 pair tweezers
- 4 oz baking soda and 8 oz table salt (make a drinking solution by adding 1 Tsp. salt and 1/2 Tsp. baking soda to 1 qt. of water)
- 1 First Aid Manual (St. John Ambulance Association)
- 1 Home Nursing Textbook (St. John Ambulance Association and/or Canadian Red Cross Society)
- 1 packet paper tissues

NOTE: individuals requiring special medication such as insulin should maintain at least a 100-day supply.

First Aid Hints

General Rules:

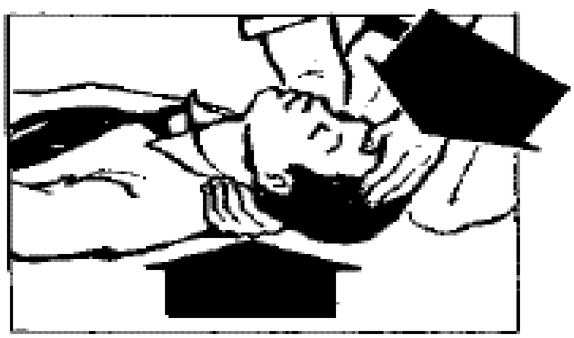
- Keep calm.
- Keep the injured person lying down in a comfortable position, his head level with his body until you determine whether his injuries are serious.
- Examine for stoppage of breathing, serious bleeding or broken bones. These must be treated immediately before any attempt is made to move the injured person. Do not be hurried into this unless you are in a situation of extreme danger.
- Keep him comfortably warm with blankets or other coverings, under and above the patient.
- Never attempt to give a semi-conscious or unconscious person anything to drink.

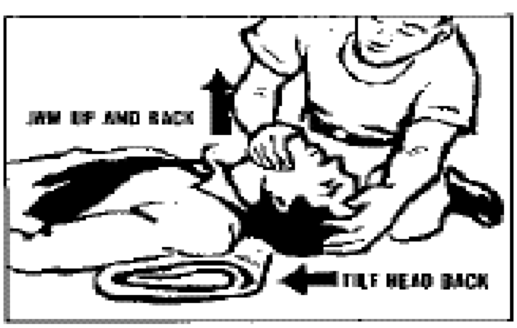
Unconsciousness:

An unconscious patient lying on his back may be strangled by his own tongue, which will tend to fall back and obstruct the airway. All unconscious persons should be placed lying half over on their faces, (three-quarter-prone position).
If the patient is breathing quietly and easily and his lips are pink and have no froth on them, breathing is not obstructed.
If the patient is breathing noisily and with difficulty, if his lips are blue and frothing, or if his chest is sucked inwards when he breathes in, his airway is obstructed and needs immediate attention.

Keep the airway clear by:

Placing the casualty on his back; supporting his shoulders on a pad of any suitable material available; tilting the head back with one hand on the forehead, the other lifting the neck.





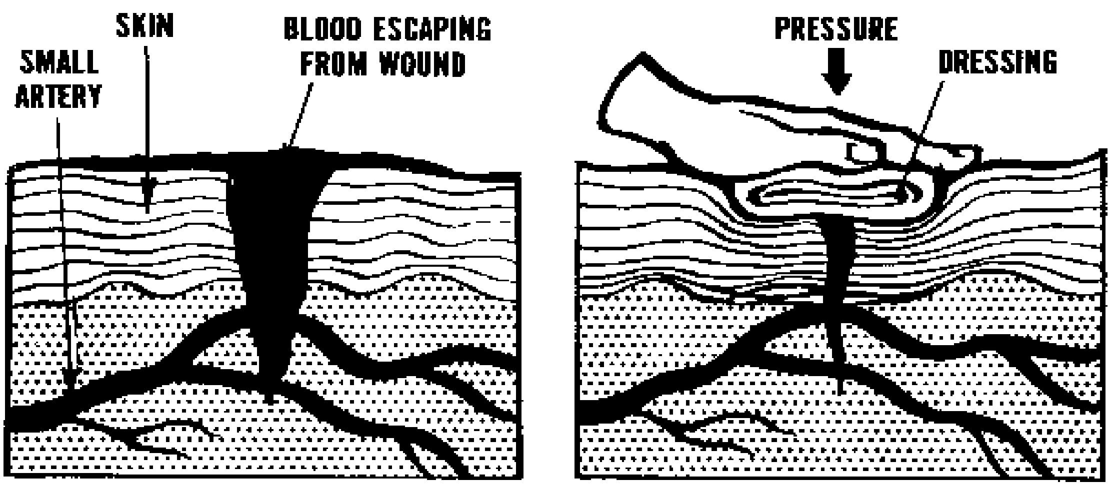
If his breathing stops you can breathe for the patient by blowing air into his lungs. Take a deep breath. Pinch the person's nostrils. Place mouth to mouth tightly. Blow into the casualty's lungs strongly enough to cause his chest to rise. The cycle should be repeated every 3 to 5 seconds for an adult and a little more frequently for a child. Blow more gently for a child or a baby, but strongly enough to make the chest rise.

Wounds:

You Must:

- Stop bleeding (hemorrhage)
- Keep out germs (infection)

Cover the wound with a clean dressing to keep out dirt and germs. Bandage it on firmly to stop the bleeding. If a wound is bleeding profusely, hold it firmly with your hand until you can secure an emergency dressing. Any thick pad of clean, soft, compressible material large enough to cover the wound will make a good dressing. Clean handkerchiefs, towels, sanitary pads, tissue handkerchiefs or sheets make good emergency dressings.



BLEEDING FROM FRESH WOUND   BLEEDING CONTROLLED BY PRESSURE

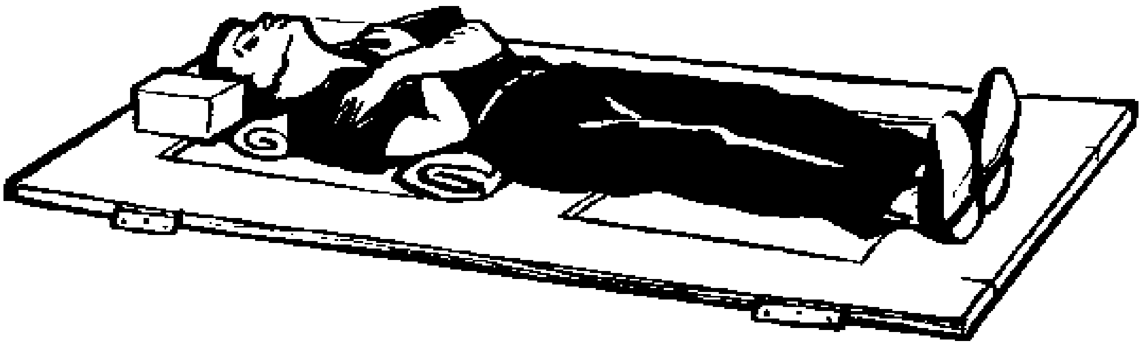
Burns:

Cover the burned area with large, thick, dry dressing and bandage it on firmly.
Encourage the casualty to drink plenty of fluids. A solution of salt and soda is useful to give to casualties with burns and to those who have suffered from serious bleeding.

Broken bones (fractures):

If a limb is very painful and cannot be used, appears to be bent in the wrong place or the casualty says he heard or felt the bone snap, it is likely that a bone is broken.
Sharp ends of a broken bone may damage important structures such as blood vessels and nerves. A broken limb should be steadied and supported to prevent movement of the broken ends before attempting to move the patient.
If a person's back or neck is so severely injured that he is afraid to move because of pain, or cannot move or feel his limbs, you should assume that he has a broken back. He should be moved on a hard, firm stretcher taking great care not to "jack-knife" him by picking up his feet and

shoulders. Improvised stretchers can be made from a door, wide board, window shutter, etc. Fill in the natural hollows of the back and neck with padding and support the head on both sides to prevent movement.



DO NOT:

- Put strong antiseptics into a wound.
- Use a tourniquet.
- Remove clothing, which is stuck to a burn.
- Break any blisters or apply creams or grease to a large burn.
- Give anything by mouth to a semi-conscious patient, or to a patient with internal abdominal wounds.

HOME NURSING HINTS

Before medical or nursing help becomes available you may also encounter infant care problems, emotional problems and persons suffering from radiation sickness. What to observe, and what to do for these latter cases, is outlined below.

Infant Care

Breast feeding is preferable but, if not possible, then a formula using powdered or evaporated milk should be prepared under clean conditions.
If vomiting or diarrhea occurs infants and children become dehydrated very quickly. To avoid this from happening, give frequent sips of clean water.
If a rash or fever develops, keep others away from the sick child.

Emotional Problems

Persons who become emotionally disturbed following a disaster should be treated calmly but firmly. They should be kept in small groups, preferably with persons whom they know and should be encouraged to "talk out" their problem. If they are not otherwise injured they should be given something to do. It may be necessary to enlist the aid of another calm person to help subdue the overexcited patient. If a stunned or dazed reaction persists over 6 to 8 hours this should be reported to a doctor or nurse immediately when one becomes available.

Radiation Sickness

The signs and symptoms of this illness are described in Step 2.
Treatment includes rest, the provision of whatever nutritional food and drink is available and personal encouragement to get well. Swab the mouth gently with a warm saltwater solution if it becomes sore. As these patients are susceptible to infection, keep wounds clean and covered with a sterile dressing. Separate these patients from persons with colds, rash or fever.

Improvised Equipment

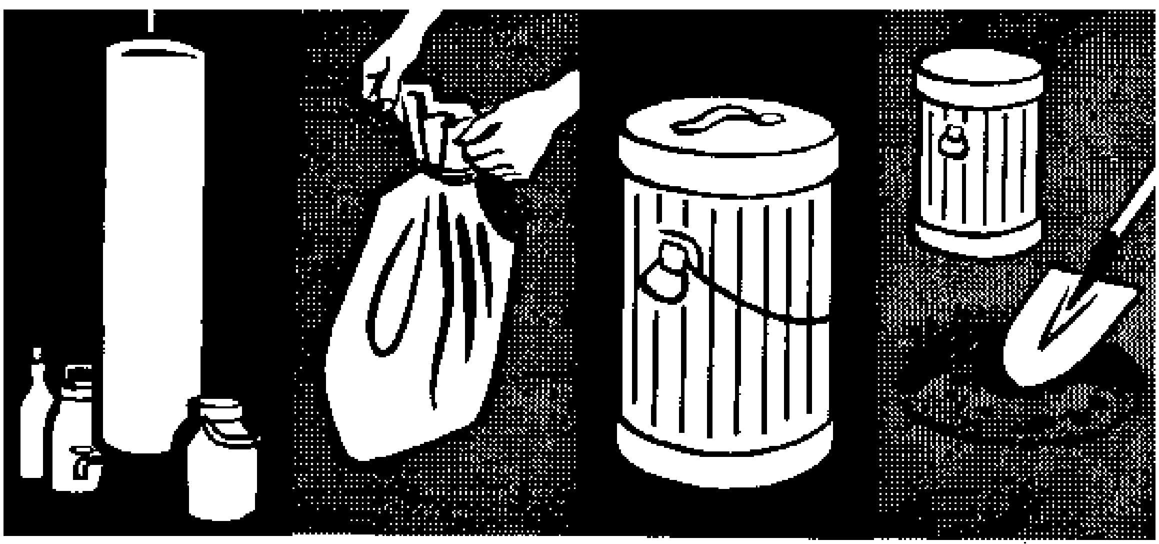
The following suggestions may help you care for your patient when proper equipment is not available.

- Bed: A couch, mattress or any well padded, firm surface; if too low raise it up on bricks, boxes or wooden blocks.
- Bedding Protection: Old crib pads cut into a convenient size and placed over a waterproof sheeting; or several layers of newspaper and heavy brown paper covered with old soft cotton. (Never use thin plastic if patient is a child.)
- Bed Cradle: A light wooden box or firm cardboard carton approximately 10 x 12 x 24 inches, with two sides removed; or a hoop sawn in half and the two pieces joined together in the center.
- Pressure Pads: Soft cushion or foam or sponge rubber pads will protect heels, elbows, back of head or any other body pressure point.
- Bedpan or Urinal: For bedpan use a padded dish or pan; for urinal any wide-necked bottle or jar.
- Hot Water Bottle: A heated brick wrapped in several layers of newspaper.

Step 8: Know Emergency Cleanliness - Back to Index

Your limited supply of water will have to be rationed and used only for essential purposes. If you have enough warning time before the arrival of fallout, fill your bathtub, all available buckets and pans with water. And remember that there is an emergency supply in your hot water tank. (Don't forget this if in peacetime your water supply has been temporarily disrupted).

The problems of garbage and human waste disposal can be solved even if fallout keeps you in the shelter. Put all your garbage in tightly covered garbage pails. After using your emergency toilet, you should tie human waste in waterproof plastic (polyethylene) bags and place them in the garbage pail. Store a 14-day supply of the plastic bags. After the second day in the shelter, you may risk leaving it for a few minutes for essential tasks. Therefore, when your garbage container is filled, move it out of the shelter.



HOT WATER TANK AS SOURCE OF WATER

HUMAN WASTE IN PLASTIC BAG

GARBAGE CAN FOR WASTE

BURY WASTE AND GARBAGE WHEN SAFE

Keep a soft broom in the shelter for tidying it up.

Remember, personal cleanliness in crowded shelter conditions is important to you and your family.

If your area is free of fallout but is without sewage services, bury human waste and garbage in the ground. Dig the pit deep enough so that the waste will be covered by at least two feet of earth.

Step 9: Know How To Get Rid Of Radioactive Dust - Back to Index

In Step 2, fallout was described as "sand". To remove the danger, remove the sand. If you suspect that your clothes have fallout on them, remove your outer clothing before you come inside your home and leave it outside. Don't shake these clothes inside the house or shelter. You would only scatter the fallout grit and create unnecessary danger to others. If you have water, wash thoroughly, particularly exposed skin and hair. But do not scrub your skin as this might rub in the radioactive particles.

Exposure to fallout does not make you radioactive.
Even if you are stricken with radiation sickness, *this sickness cannot be passed on to others*. Fallout on your clothing or body would expose you and those close to you to radiation. If you suspect you have been exposed to fallout, you will not be a danger to others if you carefully get rid of your outer clothing outside the shelter and wash.

Food and Water

Since most of your food will be in tightly covered containers (cans, bottles, plastic, boxes), it will all be safe to eat or drink if you dust the containers. Food, if it is unspoiled and free of grit or dust, may be eaten during the emergency period.

Be sure to wash fruit and vegetables and peel carefully.
Water will be safe if it is in covered containers, or if it has come from covered wells, or from undamaged water systems.

Step 10: Know Your Municipal Plan - Back to Index

It is important that your local municipality have a plan for a war emergency. And it is just as important that you know that plan.
Over the past several years, provincial and municipal governments, with the assistance of federal authorities, have been steadily developing plans for the protection of the population and the continuity of essential government services in wartime. Most municipalities in Canada have emergency plans to deal with both peacetime disasters and a nuclear attack situation. These include the details of how welfare, health, police, public utilities, fire and other emergency services will operate.
Some larger communities have developed plans to assist in the evacuation of those who would choose to leave before an attack or who might have to be evacuated as survivors or casualties following an attack. These plans include traffic arrangements to reception centers and medical facilities in nearby communities.
It would be unwise to try and prepare your own family survival plan without first checking to see how it fits in with municipal plans. This would be true whether you plan to go to a safer area before attack or remain at home. It is particularly important that you know and understand the arrangements to instruct the public about staying in shelter and coming out of shelter when it is safe. Fallout is a health hazard, which will require countermeasures for personal and family protection including assessment of radiation and advice and instructions to those in shelter.
There must be close understanding and cooperation between the public and municipal authorities responsible for their protection.
Find out about your municipal emergency plans now and keep well informed about them as they are further developed.

Step 11: Have A Plan For Your Family And Yourself - Back to Index

If you know what is contained in the first nine steps, and you know your municipal plan for a war emergency, you should now make your personal and family survival plan. The success of your plan will depend on how many of the suggested recommendations you carry out. Your chances of survival increase as you carry out each recommendation.

Thinking about the problems with which you would be faced should nuclear attack be launched against North America is the first important step. Blast, light, heat and radioactive fallout are the problems. A workable survival plan will include all of the preparations you can make in advance to meet those problems.

In making that plan, there are certain things you must know:

When to take protective action

When the sirens or other warning devices sound and your local broadcast station confirms that an attack on North America has been detected it means that you must take protective action immediately. Would you and your family

- Recognize the Attack Warning signal ?
- Turn on the radio or television and listen for instructions?

Where to take shelter

Deciding where you will take initial protective action and where you and your family will seek shelter from fallout are two basic points which you must consider in making your survival plan. Can you answer the following questions about seeking immediate protection and shelter:

- Have you decided where you will take shelter if you're not at home when the Attack Warning sounds?
- Will you try to get home?
- Will your family know what to do if you are not at home?
- Is there a shelter plan for your children at school?
- Do you want them to try to get home?
- Does everybody in your family know your survival plan?

In thinking about what you will do or where you would go, you might consider leaving your home to find shelter elsewhere. Before you decide to plan on evacuation, consider the following questions:

- Will protection there be better than in your home?
- Are there sufficient supplies there?
- Can you carry emergency supplies for 14 days?
- Do you know how to get there quickly?

How to take shelter

If you don't have a fallout shelter built in your home, study the guide given in Step 4. It shows how you can improvise emergency home protection. Bearing in mind that density and distance between you and the fallout is necessary, try to estimate if there is enough material and furniture to build an emergency shelter in your basement or the central part of your house.

- Can you move it to where it will be needed quickly?
- Will you have the help you require?

Based on the lists of emergency supplies suggested in Steps 5, 6, 7 and 8, try to answer the following questions:

- Do you have them at home?
- Can you collect and move them to the shelter area quickly?
- Does your emergency cooker, lamp, flashlight, radio work?
- Have you containers for water, garbage, hygiene?
- DO YOU HAVE A BATTERY RADIO AND SPARE BATTERIES?

There are many other points which you and your family must resolve for a workable survival plan. This booklet provides most of the essential information on which to base your plans. Read the Steps again, and, as you review each Step, try to answer the questions which apply to your surroundings, your home, your family. Here are a few more which may help:

- Do I know the recommended fire precautions?
- Does anyone in my family know how to fight small fires?
- Can an emergency supply of water be obtained quickly - for fire fighting? for personal use?
- Are first aid supplies and special medicines readily available?
- Does anyone in my family know how to render fist aid?
- Can materials for personal hygiene and cleanliness be gathered near the shelter area quickly?
- Do I know what I must do about radioactive dust?
- Do I know the emergency plans of my municipality - for public shelters? for planned evacuation routes? for schools, hospitals, welfare centers? other special instructions?

REMEMBER! YOU MUST PLAN FOR:

- **PROTECTIVE ACTION WHEN WARNED OF ATTACK and**
- **PROVISION OF SHELTER AGAINST THE EFFECTS OF FALLOUT**

On the basis of what you've read and the questions and answers you've thought about, you should now make your survival plan and start making whatever arrangements you can. BUT MAKE SURE THAT ALL MEMBERS OF YOUR FAMILY KNOW YOUR PLAN AND WHAT TO DO WHEN THE TIME COMES.

The best way to arrive at a workable plan which will be remembered by your family is to practice it. If you plan on building an emergency shelter, try it now to find out if you have enough material, how much help you'll need, if your proposed area is large enough, and how long it will take to build. Locate and practice moving essential supplies, water, clothing, bedding, etc. Practice the essential things you would have to do.

If you plan to move to what you consider a safer location, make a practice run to make sure you know the quickest and safest route, that protection is available when you get there, and that you can carry all the supplies you think you'll need.

A GOOD SURVIVAL PLAN IS A PLAN WHICH YOU KNOW YOU CAN CARRY OUT.

WRITE DOWN THE IMPORTANT PARTS OF YOUR PLAN.

List for quick reference the important things to be done in the event of warning. As examples, note when and where all members of your family will take shelter at all times; where essential items of food, shelter and other supplies will be obtained; how shelter will be improvised; what windows must be blocked; if you plan on going to what you consider a safer area, details of the route and supplies you will need at your destination.

Online Links

Nuclear War Survival Skills: http://www.ki4u.com/free_book/s73p903.htm

Potassium Iodide Anti-Radiation Pill FAQ:
http://www.ki4u.com/index.html

Civil Defense Radiation Detection Survey Meters, Geiger Counters and Dosimeters FAQ: http://www.radmeters4u.com/

Radiation Safety In Shelters, FEMA handbook for finding and providing the best protection in shelters with the use of instruments for detecting radiation: http://www.radmeters4u.com/FEMA_book/Contents.htm

How to Make and Use a Homemade Fallout Meter:
http://www.ki4u.com/free_book/s60p792.htm

Notes...

On distributing dosimeters:

a. List the serial # of each dosimeter
b. Print the name of the person to whom it is issued, next to the serial number. Then have the person sign their name to signify receipt of the dosimeter.
c. They should be instructed to wear them either in the breast pocket, or clipped to the collar, neckline, or belt.

If fallout is already starting to deposit in your area, and people are still arriving, they will have to be decontaminated. But do not allow this process to force people to stand out in the open during fallout deposition. Set up an ‘in-house’ decontamination area.

Prepare to find the places in the hospital with the lowest levels of radiation exposure. [The ground floor, inner hallways, away from any windows, etc.]. In the event of a nuclear release, TCMC will turn into a de-facto fallout shelter for hundreds of people. Safe areas need to be designated, and preparations for caring and providing for these people for up to two weeks or longer, should be considered.

Family Service Radios (at least six), for communication between the decontamination team and administration should be secured in a metal box, and each radio should be individually wrapped in aluminum foil to preserve their electronic circuits from the effects of EMP or Electro-Magnetic Pulse. An inexpensive AM/FM Shortwave Radio should also be stored and protected in this manner.

Check List…
1. Install a D-cell battery in the survey meter and perform an operational check.
2. Install a D-cell battery in the dosimeter charger and perform an operational check.
3. Charge or ‘Zero’ the dosimeters. Record the serial number of each dosimeter and the time at which it was zeroed. Leave room on the form for the name of the person to whom it was issued.
4. Give out the dosimeters and the Radiation Exposure forms.
5. All dosimeters need to be checked after 24 hours for leaks. If a dosimeter shows a reading of 2-3 Rads within 24 hours and no fallout has arrived yet, this dosimeter needs to be replaced.

FEMA
Radiation Safety In Shelters

What is Nuclear Radiation?

In the early 1900's scientists discovered that certain materials eject three different kinds of energetic rays, which they named alpha, beta, and gamma rays. These rays, or radiation, can pass through certain thickness of air, liquids, and solids much like streams of tiny bullets, but at speeds many thousands of times faster than the fastest rifle bullet. The rays cannot be seen, heard, felt, smelled or tasted.

Later, it was discovered that alpha and beta rays were very tiny particles with an electric charge that move more slowly and are less penetrating than gamma rays (which travel at the speed of light). Still later, it was found that gamma rays are packets of pure energy, called photons, which contain neither an electrical charge nor matter. Because of this property of gamma radiation, it is more penetrating than alpha or beta radiation. Visible light and x-rays are also composed of photons, except that the photons of light have much less energy than the photons of gamma rays or x-rays. Alpha, beta, and gamma radiation originate from the nucleus, or central part of a radioactive atom. This radiation is therefore called nuclear radiation.

All three kinds of radiation: alpha, beta and gamma are emitted from radioactive fallout particles produced by the explosion of nuclear weapons. Although alpha and beta radiation can be dangerous under certain conditions, (*when inhaled or ingested*), the greatest threat to human life from fallout, and the most difficult to protect against, comes from gamma radiation.

How Radioactive Fallout Is Produced

When a nuclear weapon explodes near the ground, it makes a big pit or crater. Tons of earth and debris from the crater are instantly changed from solids into hot gas and fine dust by the tremendous heat and pressure from the bomb's explosion. These hot gases and dust, together with the vaporized materials form a giant fireball that rises rapidly in the air to very high altitudes. It becomes the top part of the familiar mushroom cloud of a nuclear explosion.

Much dust and earth are sucked up with the fireball. Some of this dust and heavier particles make up the stem of the mushroom cloud. The top of the 'mushroom' spreads out, cools and forms a cloud of fine particles. These particles are carried for miles by the wind and begin to drift down to earth as fallout. The dust in the stem and in the mushroom cloud becomes radioactive mostly from radioactive materials created in the nuclear explosion that become stuck to part of the dust particles. The air around the particles does not become radioactive, and neither do the surface materials on which they settle. The heavier larger particles settle closer to the explosion than do the smaller particles, which can be carried several hundred miles by the wind. Most of the fallout will come to the ground within 24 hours. Very small particles come down very slowly and may spread over large areas of the earth's surface, over a period of many days or weeks. This delayed fallout is sometimes called 'Worldwide fallout', although most of the fallout comes down in the hemisphere in which it is produced (Northern or Southern). Fallout that arrives within the first day or two after the explosion poses a much greater threat to human life than delayed fallout.

How Nuclear Radiation Harms Our Bodies

a. ***Alpha Radiation*** **-** is stopped by the outer skin layers and isn't harmful unless fallout particles are inhaled or swallowed. In this case, the alpha radiation may cause serious damage to the tissues inside the lungs or digestive tract. However, it is unlikely that anyone will breathe or swallow enough particles to become a casualty from alpha radiation during the emergency. The fallout particles are too large to pass through the respiratory tracts without being filtered or trapped and it is unlikely that anyone will swallow large quantities of fallout particles except under bizarre circumstances. We do not need to be concerned here about alpha radiation from fallout.

b. *Beta Radiation* - is much more penetrating than alpha radiation and may cause skin burns if a lot of fallout particles less than a few days old, stay on the skin for a period of a few hours. It may also be a greater hazard than alpha radiation if fallout particles are accidentally eaten or inhaled. If fallout particles are accidentally swallowed or inhaled, some of the radioactive atoms will find their way into the bones and organs of the body, where the alpha and beta radiation may possibly cause cancer years later. Again, it is unlikely that anyone will breathe or swallow enough fallout particles to become a casualty from beta radiation during an emergency, for the same reasons as given for alpha radiation.

c. *Gamma Radiation* - is the most dangerous of the three kinds of fallout radiation, because it can penetrate the entire body and cause cell damage to all parts, to the organs, blood, and bones. If enough cells in your body are damaged by gamma radiation, you will feel sick after a while. Higher levels of exposure will cause death. Even if you are exposed to enough radiation to make you sick or possibly kill you later on, you may not feel anything while the radiation is causing damage. The reason you don't feel anything is because the nerve cells are not directly stimulated by nuclear radiation as they are by pressure and temperature.

The hazard from nuclear radiation is much reduced within a few days after fallout has arrived because all radioactivity in fallout from nuclear weapons decays by natural processes. The rate of radioactive decay is most rapid during the first few days, and gradually slows as time goes on.

How We Measure Quantities of Nuclear Radiation

We cannot weigh nuclear radiation or collect it in a box, just as we cannot weigh or collect sunshine in a box. We must measure these things by the effects they cause. Unlike the part of sunshine that we can see, invisible nuclear radiation produces an electrical effect called ionization in the materials it passes through. This ionization can be measured by special instruments.

The roentgen, [abbreviated R], is a unit of measurement for exposure to gamma and x-ray radiation. This unit is named after Professor Wilhelm Roentgen, who was the discoverer of x-rays in 1895. The harmful effects of nuclear radiation are related to the quantity of radiation to which a person is exposed. The quantity of radiation exposure will be given in units of roentgens. We use two kinds of instruments to measure nuclear radiation. One measures the total accumulated exposure to the radiation, and the other measures the rate of exposure, or how quickly radiation exposure is accumulated.

A **DOSIMETER** is a radiation detection instrument, which gives its readings directly in units of roentgens. These instruments are called dosimeters because they measure the total "dose" or accumulated amount of radiation to which they are exposed.

Another kind of instrument, the **SURVEY METER**, will measure the rate of exposure, in units of roentgens per hour [abbreviated R/hr]. These instruments are called survey meters because they can be used to look over, or survey an area to find out what the radiation levels are and find the spots where the nuclear radiation intensity is the highest or the lowest.

How Much Nuclear Radiation is Harmful?

a. **Natural Background Levels -** Low levels of nuclear radiation are a natural part of our surroundings. Radioactive elements in our own flesh and blood give off nuclear radiation, as they do in the foods we eat, the buildings we live in, and some of the water we drink. Nuclear radiation also comes from the sky and is called cosmic radiation. Nuclear radiation is part of all of our lives and has been present since the earth was formed.

In the United States, the exposure per person to natural nuclear radiation during a whole year is seldom more than two-tenths of a roentgen. These background levels of nuclear radiation are too low to be measured by the radiological instruments provided for shelters. Levels on nuclear radiation from fallout will be thousands of times higher and will be measured in roentgens per hour [R/hr] instead of roentgens per year.

b. **Symptoms of Radiation Injury -** Although nuclear radiation from the natural background damages some cells in our bodies and destroys others, we do not notice this damage. Billions of cells in our bodies die natural deaths every hour and are replaced by normal growth and repair processes. We feel no injury or sickness from exposure to nuclear radiation at the levels which exist in our natural surroundings.

But if our bodies are exposed to gamma radiation from fallout which is many thousands of times higher than the levels of natural background nuclear radiation, there will be so many cells damaged or destroyed that some of us may become sick, and some may even die. Some or all of the symptoms of injury may appear within the first three days after exposure. **These symptoms include nausea, vomiting, diarrhea, fever, irritability, a lack of energy, and a feeling of being tired. The symptoms may disappear and then come back after a week to three weeks later, sometimes with diarrhea, sore throat, loss of hair, and a tendency to bleed easily.** The greater the exposure, the earlier the symptoms will appear. They will also be more severe and last longer. Chances of illness from infections are greater among those who are exposed to more than about 200 R, because the high radiation exposure damages the immune system in our bodies that helps fight diseases. In small children, the symptoms of radiation injury will appear at lower exposures than for adults. *Even though a person may be severely affected by high radiation exposures, the person does not become radioactive from such exposure, and will not be a radiation hazard to anyone else.*

Beta burns will result if enough [to make you feel dirty or grimy] of these fallout particles, which are less than a few days old, happen to stay on the skin for several hours. Early symptoms of such skin contamination include itching and burning sensations. These may soon disappear. Darkened or raised skin areas or sores may appear within one or two weeks. After two weeks or more, there may be a temporary loss of hair, [it will return in about six months]. The greater the exposure, the earlier the symptoms will appear. Beta burns will not be a problem if fallout particles are brushed or washed off promptly. Wearing clothing such as gloves, hats, scarves, surgical facemasks, and long-sleeved garments will help to prevent fallout particles from collecting on the skin and in the lungs. Within a few days after fallout has arrived, its radioactivity will have decayed so much that beta radiation will not be a hazard under most circumstances. It may be a problem in the first few weeks if a person must lie or crawl on the ground, as may be necessary in rescue operations, and the skin is covered with dust, which is not removed for many hours.

We are concerned mostly about radiation injury from gamma radiation from fallout particles on the ground, on buildings, trees, and shrubs around us. This radiation is called external radiation because it comes from particles, which are outside the body.

c. **Effects and Levels of Sickness from Brief Exposure -** When people are exposed to gamma radiation from fallout, their entire bodies are exposed, including arms, legs, head, and trunk. This kind of exposure, called whole-body exposure, differs from medical exposures in which radiation may be concentrated on one small part of the body. A whole-body brief exposure of 50-200 R of gamma radiation may result in radiation sickness, but if only a part of the body such as the hand or foot is exposed to 50-200 R of gamma radiation, as in medical treatment, there will be no radiation sickness.

The human body has ways of repairing the damage done to it. Because of these repair mechanisms, a whole-body radiation exposure of 600 R spread out uniformly over a period of 20 years would not cause any radiation sickness. But if this exposure were received over a brief period of a week or less, it would probably result in death.

Some people may become very sick within a few weeks after being exposed for a brief time [a week or less] to a certain amount of gamma radiation from fallout. Others may be exposed to the same dose and not feel any serious effects. If the exposure is less than 50 R, the injury from radiation should not produce symptoms in anyone. Some people irradiated in this dose range might experience loss of appetite and nausea, but this could also be the result of anxiety and fear.

Doctors have described five levels of sickness which occur after brief whole-body exposure to 50R or more of gamma radiation from fallout. These levels are described here and summarized in Table 1-1. Additional effects are described in the books listed in the Bibliography, Appendix C. Table 1-1. Levels of sickness and probable conditions of most people after brief whole-body exposure to gamma radiation.

Exposure	**Response**	**Medical Care Required**	**Death Rate**
0 - 50R	**No symptoms**	**NO**	**0%**
50 - 200R	**Radiation Sickness Level I**	**NO**	**Less than 5% Death: 60 days +**
200 - 450R	**Radiation Sickness Level II**	**YES**	**Less than 50% Death: 30-60 days**
450 - 600R	**Radiation Sickness Level III**	**YES**	**More than 50% Death: 30 days +/-**
600R - or higher	**Radiation Sickness Levels IV and V**	**YES**	**100 % death rate under two weeks**

- -

(1.) **Level I: 50 to 200R Exposure** - Less than half of the people exposed to this much radiation experience nausea and vomiting within 24 hours. Afterwards some people might tire easily, but otherwise there are no further symptoms. Less than five percent [one out of 20] need medical care. Any deaths that occur after radiation exposure are probably due to additional medical problems [complications] a person might have at the same time, such as infections and diseases, injuries from blast, or burns from the nuclear thermal pulse.

{2.) **Level II: 200 to 450R Exposure -** More than half of the people exposed to 200-450R experience nausea and vomiting and are ill for a few days. This illness is followed by a period of one to three weeks when there are few if any symptoms [a latent period]. At the end of this latent period, more than half of those exposed experience loss of hair. A moderately severe illness develops which is often characterized by sore throat. Radiation damage to the blood-forming organs results in a loss of white blood cells, increasing the chance of illness from infections. Most of the people in this group need medical care, but more than half will survive without treatment. The chances of living are better for those with smaller doses and those who get medical care. More than half are sick the first few days, but less than half die.

(3.) **Level III: 450 to 600R Exposure -** Most of the people exposed to 450-600R experience severe nausea and vomiting and are very ill for several days. The latent period is shortened to one or two weeks. The main episode of illness which follows is characterized by much bleeding from the mouth, throat and skin, as well as loss of hair. Infections such as sore throat, pneumonia, and enteritis [inflammation of the small intestine] are common. People in this group need intensive medical care and hospitalization to survive. Fewer than half will survive in spite of the best care, the chances of survival being poorest for those who received the largest exposures.

(4.) **Level IV: 600 to over 1,000R Exposure -** This level produces an accelerated version of the illness described for Level III. All the people in this group begin to experience severe nausea and vomiting. Without medication, this condition can continue for several days or until death. Death can happen inn less than two weeks, without the appearance of bleeding or loss of hair. It is unlikely, even with extensive medical care, than many will survive this exposure.

(5.) **Level V: Several Thousand Roentgens Exposure -** Symptoms of rapidly progressing shock come on almost as soon as the dose has been received. Death occurs in a period from a few hours to a few days. It is highly unlikely that exposures to this magnitude will be experienced in fallout shelters.

d. **Long-Term Effects:** In addition to early sickness, exposure to nuclear radiation has some effects which may not show up for months or years. In a nuclear war, our first concerns will be with survival from the early effects. If the levels of nuclear radiation are low enough so that early radiation sickness is not a serious factor, then we become concerned with avoiding long-term effects. After a period of months to years has passed following an exposure to nuclear radiation levels many times higher than background levels, some of the people [less than a few percent] may develop various kinds of cancers. The probability of developing such late effects should not be used as a principal determining factor in decision making during a war emergency, but such effects can and should be minimized by keeping controllable exposures as low as practicable.

There may also be effects on babies exposed while in the womb and genetic effects in children whose parents [one or both] were exposed to high levels of radiation. Pregnant women who are exposed to enough radiation to cause symptoms of early radiation sickness (over 50R), as described above, may have a miscarriage. There may be some developmental defects in the few babies born to the heavily exposed mothers.

Additional information on long term effects may be found in the books listed in the Bibliography, Appendix C.

e. **Contamination of Food and Water -** Food and water that have been exposed to nuclear radiation but are not contaminated by fallout particles are not harmed and are fit for human consumption, unless spoiled in some other manner. If food containers, fruits, vegetables, and grains become contaminated by the presence of radioactive fallout particles, they need not be thrown away. If the particles can be removed by washing, scrubbing, brushing or peeling, the food is safe for consumption.

Water in covered containers and from underground sources will be safe. **Water into which fallout particles have fallen may become unsafe to drink for a while, because radioactive iodine dissolves in water**. Water that is collected from rooftops or other flat areas into cisterns, tanks, or other reservoirs, may have much higher concentrations of radioiodine than other sources of water if there is a rainfall shortly after fallout has arrived. Rivers and streams that are fed mostly by water from the surface rather than from underground springs may also become contaminated by radioiodine if there is a rainfall in the first few days after fallout arrives. Water in large, deep lakes, reservoirs, and rivers will probably be safe to drink [although it could still be unsafe due to other pollutants] within several hours or days after fallout has arrived, because of dilution of the radioiodine into large volumes of water.

The radioiodine problem will almost completely disappear in any water in a few weeks due to natural radioactive decay. The quantity of the radioactive iodine of greatest concern will become half as much every eight days [the half-life is eight days].

Radioisotopes that have dissolved in water cannot be removed by boiling or settling. The water can be purified by special filtering or chemical processes, one method being the filtration of water through several inches of soil or clay [not sand]. Water filtered through soil must be disinfected either by boiling or by adding chemicals such as chlorine [**Regular Clorox bleach: 8 to 10 drops per gallon**], or household iodine.

Even low levels of radioiodine in water, undetectable by the radiological instruments described in this handbook, may cause special medical problems in some people. Radioiodines may become concentrated and stored in the thyroid gland, resulting in possible radiation damage to the thyroid in some people and after several months or years, thyroid tumors, hypothyroidism [goiter], or thyroid cancer may develop. These symptoms, except radiation damage, may be treated medically. Infants and fetuses are more susceptible to this threat than older children and adults. In any case, **NO ONE SHOULD BE DENIED WATER BECAUSE OF POSSIBLE FALLOUT CONTAMINATION.**

The concentration of radioiodine in the thyroid gland can be blocked by taking pills or drops of potassium iodide [KI]. If the gland is saturated with non-radioactive iodine, it will not take up radioactive iodine that enters the body by any other means. However, taking potassium iodide does not provide protection against gamma radiation from outside the body.

The Food and Drug Administration has declared potassium iodide for use in radiation emergencies to be a non-prescription drug. Potassium iodide pills may be obtained at many drugstores. Some states are stockpiling potassium iodide pills to be used in the event of a radiation emergency involving a nuclear reactor.

For children and adults, the recommended dose of potassium iodide is 130 milligrams taken by mouth each day, for 14 days. Unless it becomes known before the 14 days are up that the drinking water is not contaminated or a source of uncontaminated water is found. If the same drinking water must be used all the time without knowing whether it is contaminated, the potassium iodide dose may be reduced after 14 days to half a pill [or 65 mg.] taken by mouth each day by children and adults. Children under one year of age may be given half the dose taken by adults, although the adult dose would be safe. Taking more than one 130 mg. tablet per day will not improve the blockage of radioiodine. For best results, the dosages should be started preferably before drinking water suspected of being contaminated but not later than three to four hours after drinking such water. Side effects from this dosage are expected to be very rare. Persons with KNOWN ALLERGIES to iodine SHOULD NOT take this medication.

How You Can Shield Yourself from Gamma Radiation

You can protect yourself from bullets by surrounding yourself with armor plate. In a similar way, [but not exactly!], you can shield yourself from gamma radiation. Anything between you and the source of gamma radiation will cut down the number of rays that reach you. The heavier or more massive the barrier between you and the source, the more the radiation is cut down.

A wall of concrete will give better protection than a wall of earth of the same thickness, because the concrete wall is heavier. Concrete has a greater density than earth. But if the concrete wall is thinner than the earth wall, [but the same height and width], so that the overall weight is the same, each wall will give the same protection. It's not the thickness, but the total weight of materials between you and the fallout that is important.

A wall of a certain thickness will stop a bullet of a certain size and speed without any doubt. For gamma rays, a wall only cuts down the chances of the gamma 'bullets' getting through. A wall of concrete eight inches thick will cut down the gamma radiation from fallout by about a factor of ten. Other materials will reduce the radiation more or less effectively, depending on whether their specific gravity or density is greater or less than that of concrete.

To give you an idea of which common materials might be useful for shielding, a list of materials is given in Table 1-2, showing their densities compared with concrete. Note that earth is almost as good as concrete and is usually available and inexpensive. Water and gypsum wallboard are better shielding materials than wood and newspapers. Lead is the most dense shielding material of those listed. Lead bricks and sheets are often used as shielding material where little space is available, but are too expensive for general use in shelters.

Table 1-2. A list of materials to give you an idea how good they would be as barriers against gamma radiation from fallout. [Materials with the highest densities require less thickness to cut down the gamma penetration by a given amount].

Material	Density to concrete	Thickness to concrete
Aluminum	1.2	0.8
Brick, common clay	0.7	1.4
Concrete	1.0	1.0
Earth (well-packed moist humus, dry clay)	0.7	1.4
Firebrick (used in fireplaces)	0.9	1.1
Glass	1.1	0.9
Hardwood (Maple or Oak)	0.3	3.3
Human Body	0.4	2.5
Lead	4.9	0.2
Magazines, (slick)	0.4	2.5
Newspaper (flat), books, pulp magazines	0.3	3.0
Plywood (dry)	0.2	5.0
Steel	3.4	0.3
Wallboard, gypsum	0.4	2.7
Water	0.4	2.3

When fallout particles are all around you on the ground outside the shelter, you will need a barrier all around you to shield yourself from gamma radiation. You will also need a barrier ABOVE you, even though the fallout particles may have already settled to earth. An overhead barrier is needed because gamma radiation is scattered by air, somewhat like auto headlights are scattered by fog. The scattered gamma radiation can reach you from above. This scattered radiation from above is called “skyshine” and is not as penetrating as the radiation coming in a straight line directly from fallout. Fallout may settle on roofs or hillsides above your shelters, and the direct radiation from this fallout will add to the overhead radiation from scattered gamma rays. If you are in a shelter, which is below ground, you will need to be concerned mostly with overhead radiation.

Gamma radiation is also scattered around the corners of tunnels and corridors by the air and by the material in the walls. The intensity of gamma radiation scattered around corners is much less than that of the direct radiation.

Because of the penetrating and scattering nature of gamma radiation, the unevenness of fallout, and the different thickness’ of materials between you and the fallout at different places in the shelter, you will need to use the radiation survey meter to find places where the radiation levels are lowest in the shelter. You may improve the shelter and make the radiation still lower by using available materials to build barriers between you and the strongest sources of radiation. The survey mater will tell you how well you have succeeded.

How Fallout Radioactivity Arrives and Decays

As fallout settles on the shelter and its surroundings, the needle on the survey meter may climb steadily for some time. On the other hand, if you are well protected or if the fallout is not heavy in your location, you may see little or no indication on the survey meter. The fallout cloud or clouds may take as little as 15 minutes or as long as several hours to arrive and begin to deposit fallout in your area.

a. **Fallout from One Weapon -** If the fallout comes from only one relatively small nuclear weapon exploded on or near the ground less than 20 miles upwind, the fallout may start to fall on the shelter in less than an hour after the explosion. After the fallout begins, it may keep on coming down for an hour or so. If you are outside (where you should not be unless you are on your way to shelter or there is an extreme emergency) you may be able to see some very fine particles coming down. You may also notice a darkness in the sky and feel gritty particles strike your face. After several minutes, a buildup of a thin layer of fallout dust may be noticeable on the tops of cars and on window ledges. If the fallout is visible, the radiation levels are hazardous.

b. **Fallout from Many Weapons -** If the fallout comes from many large weapons exploded on or near the ground 100-200 miles upwind, the fallout may not start to fall on your shelter for many hours. The time it takes for the fallout clouds to arrive at your location depends on how far upwind the explosions were and on how fast the winds carry the clouds. After the fallout begins, it may keep on coming down for several hours. Larger particles from the explosions will fall to the ground faster than the smaller particles. The clouds will contain mostly very small particles or fine dust by the time they arrive at the shelter, if it is well downwind of the explosion. This dust may be too fine to feel or see, although a darkening of the sky may be noticeable. The buildup of dust on surfaces will be gradual and won’t be obvious. The nuclear radiation exposures from this almost invisible fallout may be just as great as, or greater than the radiation exposures from the more visible fallout from explosions that are closer.

There will be a clout of fallout particles formed by each of the ground explosions. Some of the clouds may merge. As each cloud with it's trail of fallout passes over your shelter, the needle on your radiation survey meter may climb to higher levels.

c. **After Fallout Stops Coming Down -** After a fallout cloud passes by and when almost all the fallout particles from that cloud have reached the ground in your area, the surbey meter needle will slowly begin to fall as the radioactivity from fallout decays and fades away by natural processes. The radioactive materials produced by the nuclear bomb explosion are unstable. These materials change (or decay) into a stable condition by shooting out nuclear radiation. Some materials decay into their stable form faster than others. Those that change fast are very busy producing intense nuclear radiation in the first few moments after a nuclear explosion. Those that decay more slowly may be responsible for measurable nuclear radiation years after the explosion.

d. **The Seven-Ten Rule -** Because many materials in the fallout cloud decay quickly, the nuclear radiation from a given quantity of fallout is most intense in the first moments after detonation and its intensity rapidly falls to lower levels. This behavior can be approximately described by a rule of thumb called the 'seven-ten' rule. This rule APPLIES ONLY TO FALLOUT OF THE SAME AGE. If the fallout at a location is a mixture resulting from detonations that took place at different times, the seven-ten rule does not apply.

THE SEVEN-TEN RULE - States that the measured radiation intensity from a given quantity of fallout particles will decay to (1) ONE_TENTH AS MUCH when the fallout becomes SEVEN TIMES OLDER than the age at the time of measurement, (2) ONE-HUNDREDTH (1/10 x 1/10) AS MUCH when the fallout becomes FORTY-NINE TIMES (7 x 7) OLDER than the age at the time of measurement, and so forth. The unit of time can be seconds, minutes, hours, half-days, days or whatever period of time is appropriate for the situation. The seven-ten rule is illustrated in Figure 1-2.

Suppose that fallout begins to arrive at a certain location two hours after the explosion, and the fallout keeps on coming down for three more hours before it stops. The seven-ten rule cannot be used with survey-meter readings taken while fallout is arriving, because the quantity of fallout is increasing. At five hours after the explosion, when the fallout at this particular location has clearly stopped, the survey-meter reading can be used with the seven-ten rule to predict the future radiation intensity at the location. If no additional fallout arrives, and weather doesn't change the fallout pattern. In this case, the age of the fallout (or the time 'T' after detonation, according to Figure 1-2) is five hours.

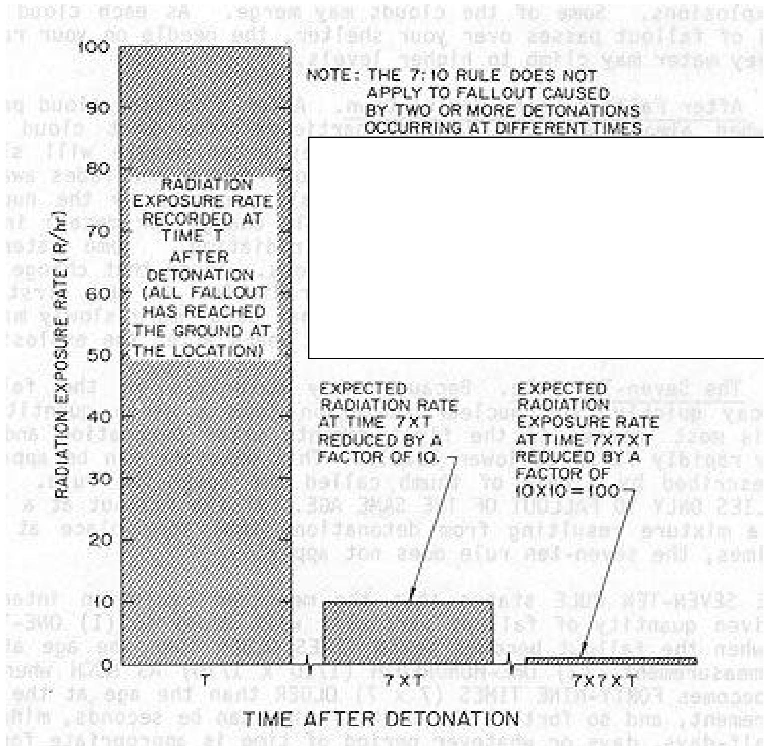


Figure 1-2. The seven-ten rule. The time 'T' after detonation is the age of the fallout.

The seven-ten rule states that the radiation intensity at this location at 7 x 5 hours, or 35 hours after the explosion, will be reduced by a factor of 10 to $1/10^{th}$, or 10 % of the reading obtained at five hours. Furthermore, the seven-ten rule states that for two multiples of seven, or at 7 x 7 x 5 hours, or 7 x 35 = 245 hours (10 days and 5 hours) after the explosion, the radiation intensity at this location will be reduced by two factors of ten to $1/100^{th}$ (1/10 x 1/10), or one percent, of the reading obtained at five hours after the explosion.

If another reading is taken at this location when the fallout is nine hours old, the seven-ten rule states that the intensity at 7 x 9 = 63 hours after the explosion will be reduced by a factor of 10 to $1/10^{th}$ the reading at nine hours, and the intensity at 7 x 7 x 9 = 441 hours (18 days, 9 hours) will be reduced by a factor of 100.

If there are several nuclear ground bursts detonated at different times upwind or if there is a heavy rain during or after the fallout, the seven-ten rule does not apply. Other rules have been developed to forecast upper limits of radiation exposure, as described in paragraph 4-5a.

e. **Radioactive Decay** - Decay of the radiation intensity from radioactive fallout particles takes place in the cloud as it is carried by winds toward you. The radiation intensity will also be decreasing because the cloud spreads out as it moves along, and the heavier particles will be dropping out, so the number of fallout particles per cubic inch of air will be decreasing as time gods on. Radioactive materials in the clouds from distant explosions will have more time to decay and spread out while they are on their way. Many of the materials that decay quickly will have decayed to undetectable levels before reaching you. For this reason, the radiation intensity from fallout on the ground from distant explosions will decrease more slowly when it reaches the ground than the radiation intensity of fallout from closer explosions.

f. **Rainout -** If the air is humid, the nuclear explosion may start a local rain. If it is already raining or if the explosion starts a rain shower, much of the radioactive material will come quickly to the ground as ‘rainout’. When rainout occurs soon after an explosion, the fallout cloud has not had a chance to spread out as it does when carried a long way by the wind, and it has not had as much time to decay.

If the rainfall producing rainout is light, local radiation intensities may be much higher than when produced by dry fallout. If the rainfall is heavy, the radioactive material may be washed into gutters, ditches, and storm sewers. From there, it may flow into streams and rivers. Radioactive materials, like dirt particles, can collect in unpredictable locations under these circumstances. The radiation survey meter will be needed to help detect, and avoid remaining in, such locations.

CHAPTER 2
INSTRUMENTS FOR DETECTING NUCLEAR RADIATION

2-1. **What Is Needed -** If radioactive fallout settles on a shelter and its surroundings, people in the shelter will want to know where to go and what to do for the best protection. People in your shelter will want to know whether they are going to get sick and possibly die from radiation exposure. After the worst radiation has faded away, they will want to know the risks of going outside, how long they can stay outside, and which locations will result in the least radiation exposure. To answer these questions, you will need special instruments.

The levels of radiation from fallout from nuclear weapons can be much higher than those encountered in peacetime conditions. The radiation instruments developed for use by operators of nuclear reactors, by radiation therapists in hospitals, or by crewmen or nuclear submarines and ships are generally not suitable for the needs of people caught in the radioactive fallout of a nuclear war. These commercial instruments for peacetime purposes usually do not have the higher ranges which may be needed for wartime use.

To meet the special needs of people who may face radiation hazards from radioactive fallout that may result if this country is attacked by nuclear weapons, the U.S. Government has developed two kinds of radiological instruments. The **SURVEY METER** is designed to help you find the places of lowest radiation intensity and to indicate where you should not go because of high radiation levels. The **DOSIMETER** IS DESIGNED TO HELP YOU ESTIMATE THE TOTAL AMOUNT OF RADIATION TO WHICH YOUR BODY HAS BEEN EXPOSED. Without a dosimeter it would be difficult to estimate exposure to radiation if you need to move around in places where there are different radiation intensities or if the radiation intensity rises and falls irregularly due to fallout from passing fallout-laden clouds.

2-2. **What If There Are No Instruments? -** If people have assembled in a shelter in a nuclear war emergency and there are no radiation detection instruments, try to obtain these instruments from your local government before fallout arrives (see STEP 2a of Checklist ‘A’). If no radiological instruments can be obtained, try to find the location in your shelter that you think will provide the best protection from nuclear radiation (see paragraph 4-2b, ‘Checking out the Shelter’). Listen to your local radio station, particularly one which is tied in with the Emergency Broadcast System (EBS), for news of approaching fallout.

If there are no radiological instruments, then you will need communications with those who have them. You will need information from others, from your local Emergency Operating Center, if possible, or from EBS. If you have no radiological instruments, communications may provide the only warning of the arrival of a radiation hazard. Remember, although the particles may be seen, heard, and felt under some conditions while they are coming down, the fallout radiation itself is invisible and silent and cannot be felt.

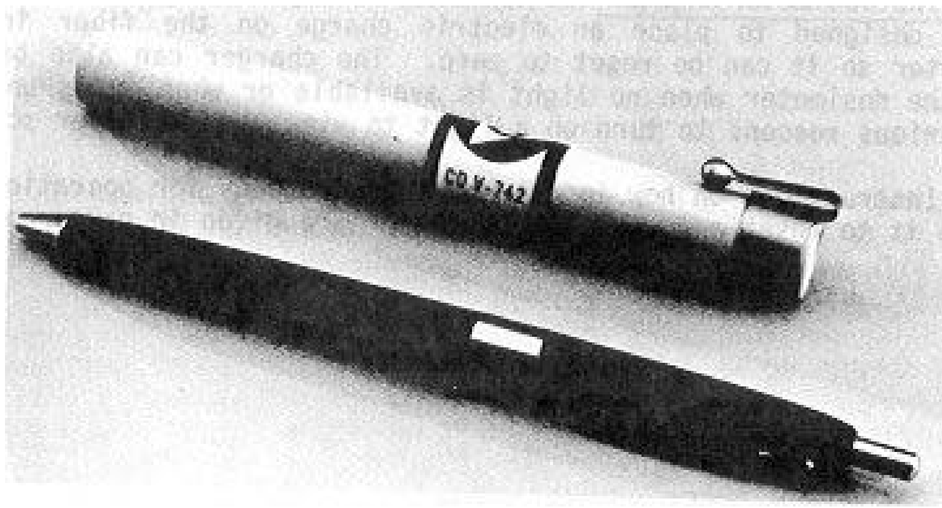
2-3. **The Survey Meter** - A survey meter is illustrated in Figure 2-1. The gamma-radiation level (exposure rate) is shown by the position of the needle on the instrument dial. When the needle points to a number on the dial, that number, when multiplied by the range-selector number (described in paragraph 3-2d [2]), will tell you the level of gamma radiation from fallout in units of roentgens per hour (R/hr) at the location of the instrument.

Gamma rays pass through the metal case of this instrument and also through the walls of a metal can (called the ionization chamber) inside the case. The ionization chamber is sealed to keep out moisture and dust and to maintain a constant pressure. Some of the gamma rays produce charged particles inside the ionization chamber, and these charged particles are collected to make a tiny electric current. This electric current is amplified by electronic circuits in the survey meter to make a much stronger current, which moves the needle. If the survey meter is moved to a location where there is negligible gamma radiation, the needle will return to the zero position.

Radiation levels from fallout in a nuclear war can be very high. The highest reading on the survey meter is 500 R/hr. Because of the large range of radiation levels which you might encounter, from low to very high, this instrument was designed with a range-selector switch. If this instrument had no range-selector switch, a low but still hazardous radiation exposure rate of 5 R/hr would cause an almost undetectable needle movement. This situation would compare with trying to read the speed of a car going one mile per hour on a speedometer that reads 100 mph full scale. By switching the range-selector switch to a different position, the maximum range of the needle can be changed from 500 R/hr to 5 R/hr. The radiation exposure rate of 5 R/hr would then cause the needle to swing all the way through its full range of movement to the high end of the scale. With another position of the range-selector switch, readings as low as 0.05 R/hr can be read accurately.

Instructions on how to get the survey meter ready for operation and how to use it are given in paragraph 3-2.

2-4. **The Dosimeter -** A dosimeter is shown in Figure 2-2 with a ball-point pen for comparison of size. The dosimeter has a clip so it can be attached to clothing worn on the body. It is usually worn in a breast pocket. If a person's clothing has no breast pockets, the dosimeter can be clipped to the collar, neckline, or belt. In some situations, dosimeters may be mounted on walls, posts, or furniture or hung by string.



The dosimeter shows the total or accumulated amount of gamma radiation to which it has been exposed starting from the time of recharging (or zeroing) the instrument. This gamma exposure is read by holding the instrument so that it is pointed toward a bright light and looking through one end, the end with the clip on it. The gamma exposure is shown by the position of a hairline along a scale of numbers marked 'ROENTGENS'. The scale has numbers that begin with zero at the left side and usually end with 200 at the right side.

The dosimeter is constructed to be reliable and rugged. The only moving part is the hairline or fiber seen through the eyepiece. Its design is based on the principle that a charge of electricity is reduced when there are charged particles around, and charged particles are produced by gamma radiation. A special instrument is used to place a charge of electricity inside the dosimeter. This charge is just like the static electricity that builds up on a person who is walking along a carpet on a dry winter day. The position of the fiber depends on how much static electric charge is on it. When gamma rays interact with the walls of the dosimeter and enter the chamber in which the fiber is sealed, charged particles are produced. These particles reduce the charge on the fiber, and the fiber moves to a different position. The position of the fiber as it is seen on the scale then indicates the total amount of gamma radiation to which it has been exposed since it was charged.

Instructions on how to get the dosimeter ready for operation and how to use it are given in paragraph 3-4.

2-5 **The Dosimeter Charger -** A dosimeter charger is shown in Figure 2-3. It is designed to place an electric charge on the fiber inside the dosimeter so it can be reset to zero. The charger can also be used to read the dosimeter when no light is available or when it is undesirable for various reasons to turn on a light to view the dosimeter scale.

Instructions on how to get the charger ready for operation and how to use it to reset and read the dosimeter are given in paragraph 3-3.

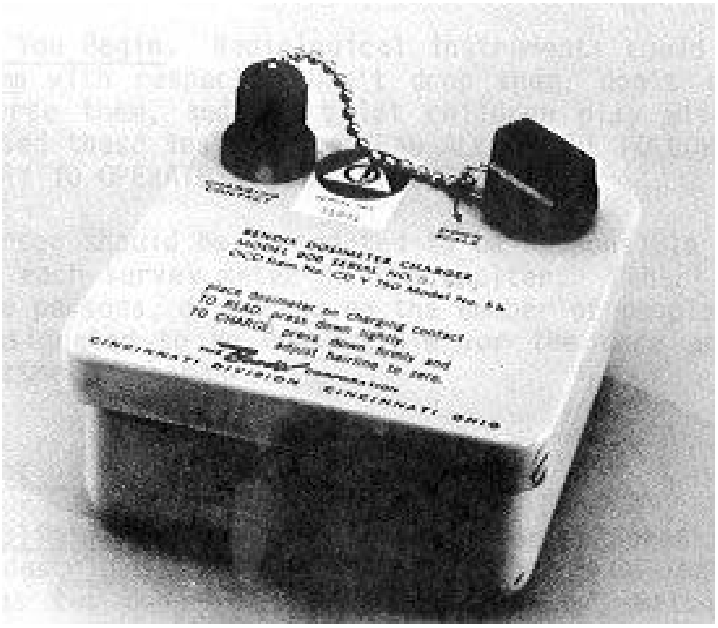


Figure 2-3. Dosimeter Charger

Chapter 3

HOW TO GET YOUR RADIOLOGICAL INSTRUMENTS READY FOR OPERATION

3-1. **Before You Begin -** Radiological instruments could save your life, so treat them with respect! Don't drop them, don't spill liquids on them or immerse them, and don't let children play with them. If you have never used these instruments READ ALL OF THE FOLLOWING INSTRUCTIONS BEFORE YOU TRY TO OPERATE THE INSTRUMENTS..

One person should be designated to be responsible for the care and operation of each survey meter in the shelter. Other persons, or perhaps the same persons, depending on the number of people in the shelter, should be designated to be responsible for the care and use of dosimeters and dosimeter chargers.

3-2. **Preparation for using the Survey Meter**

a. **Preliminary -** What the survey meter measures and how it works are briefly described in paragraph 2-3. The survey meter (Figure 2-1), has two controls: the range-selector switch underneath the handle and the zero control on the corner. A carrying strap will be appreciated in a fallout situation when you may need to use your hands to do something else and you don't want to put down the instrument.

b. **Installing the battery in the Survey Meter -** The survey meter is powered by a single D-cell flashlight battery. The battery is installed as follows:

1. Turn the range-selector switch (the switch underneath the handle) to the 'OFF' position.

2. Open the case by unfastening the case clips at each end.

3. Use the handle to lift the top part of the survey meter out of the bottom part of the case. The top may be laid on a flat surface or held in the hand by the handle while installing the battery.

Don't let dust, sand, or moisture get in the case. If fallout particles get inside the case, you will get a false reading! Also, don't let anyone touch the circuit board or other interior parts. Grease or sweat on the electronic components may cause a malfunction.

There may be a packet inside the survey meter, which may or may not be labeled 'desiccant'. Leave the packet inside the case. Don't get it wet! It will help keep the inside dry. Dryness is necessary to prevent small electric currents from leaking across insulators and to prevent corrosion.

4. Install the D-cell battery in the rectangular plastic battery holder that is mounted on the inside of the top cover. The inside of the top cover with a battery inserted is shown in Figure 3-2. One end of the floor of the battery holder will be marked with a plus sign [+] and the other end with a negative sign [-]. The battery may also be marked with these signs but, if it isn't, the positive end can be identified by the raised center post. Insert the battery in the holder so the plus sign [+] on the battery or the positive electrode is on the end where the plus sign [+} is marked on the floor of the holder. Push the battery in firmly so the metal electrode clips on the ends of the holder snap over the battery ends and the battery is down in the holder as far as it will go.

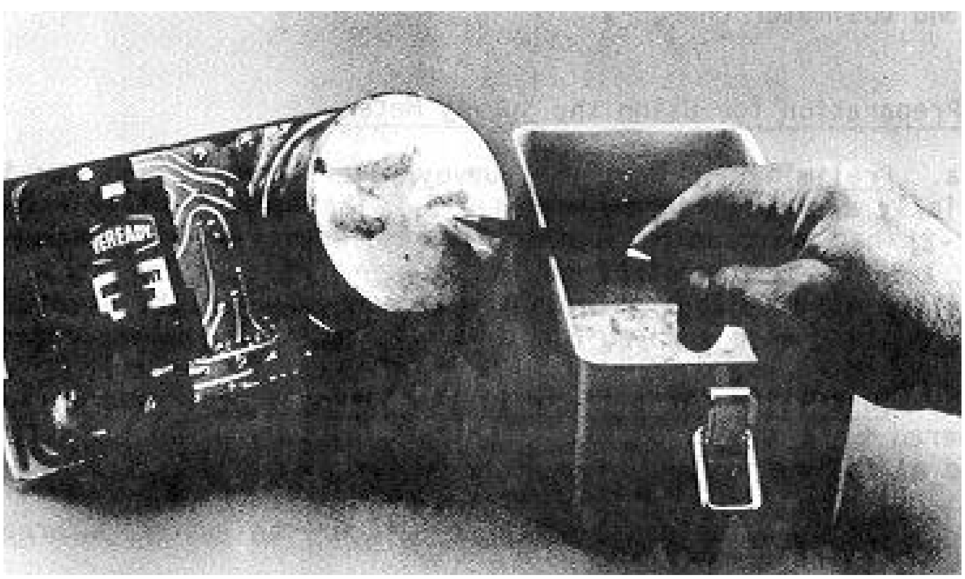


Figure 3-1. A survey meter with the top removed. The top is shown upside down on the left. The pen points to the ionization chamber.

5. Lower the top part of the survey meter into the bottom part of the case. If there is a small rubber pad glued on one end of the inside floor of the bottom part, turn the case so the pad lines up under the battery.

6. Fasten the case clips.

c. **Checking the battery and the instrument [Operational Check] -** Every time a battery is inserted in the survey meter, an operational check should be made to make sure the battery has been put in correctly and that it has enough energy to run the survey meter. An operational check should also be made each time before using the survey meter to make sure the meter is operating properly. An operational check is made as follows:

1. Turn the range-selector switch (the switch underneath the handle) to the ‘ZERO’ position. Wait a full two minutes before doing anything else with the meter. One of the components in the survey meter is a special electronic tube (an electrometer tube), which must be warmed up before it can operate properly.

2. After waiting two minutes for warm-up, rotate the knob marked ‘ZERO’, (the knob on the corner) until the needle on the meter points to ‘0’ (zero). If the needle doesn’t move when the ZERO knob is rotated, turn the range-selector switch to ‘OFF’ and remove the battery. Clean the battery contacts and install a new battery, unless the old one is known to be good. If the needle still doesn’t move with rotation of the zero control, then the instrument is faulty and should be returned for replacement, if you have the time and opportunity.

3. After the instrument has been zeroed, turn the range-selector switch to ‘CIRCUIT CHECK’ and hold it there against the spring pressure, which will return the switch to ‘OFF’ when the switch is released. While holding the switch in the ‘CIRCUIT CHECK’ position, the needle should climb to the upper part of the meter scale in or near the area marked ‘CIRCUIT CHECK’. A reading of 3 or higher (even though the area marked ‘CIRCUIT CHECK’ begins at 3.5, not 3.0) will tell you three things: (a) the battery was installed properly, (b) the battery has enough energy to run the meter, and (c) the circuits involved in this part of the test are operating properly.

If the needle does not climb up to 3 or higher while the range-selector switch is being held on ‘CIRCUIT CHECK’, remove the battery, clean the battery contacts, and install a new battery, unless the old one is known to be good. Repeat the steps above, including the zero adjustment. If the needle still does not climb up to 3 or higher during the circuit check, the instrument is faulty and should be returned for replacement, if there is a place close enough where you may replace it and get it back before fallout arrives.

4. After the survey meter has passed the circuit check satisfactorily, rotate the range-selector switch to each of the positions marked ‘X100’…’X10’…’X1’…and ‘X0.1’. Let the switch rest at each position momentarily, and observe the position of the needle on the meter. If there is no gamma radiation present besides that from normal background radiation, the needle should remain approximately at zero at each position of the switch. If it moves up-scale, it should not move up more than three of the smallest divisions (not above 0.3 reading on the dial) when the range-selector switch points to ‘X100’, ‘X10’, or ‘X1’. When the range-selector switch points to ‘x0.1’, the needle should not move up-scale from zero more than six of the smallest divisions (not above a 0.6 reading on the dial).

This smallest needle movement, called up-scale leakage, will not affect the usefulness of the survey meter in detecting hazardous radiation levels from fallout. If the up-scale leakage is greater than the limits stated above, the amount of up-scale leakage usually can be reduced significantly by leaving the instrument on for one to 16 hours with the range-selector switch in the ‘ZERO’ position. This procedure reconditions the electrometer tube. If excess up-scale leakage still exists after 16 hours of reconditioning, and there is no fallout gamma radiation present, other problems exist. The instrument should be returned for replacement if you have the time and opportunity.

Be sure to turn the range-selector switch to the ‘OFF’ position when the survey meter is not in use.

d. **Reading the survey meter -** After the operational check has been made, the survey meter can be used to measure the gamma radiation exposure rate at the location of the meter, as follows:

1. Hold the meter steadily in one location at about three feet of the floor (waist height) and about two feet away from your body. The meter is to be held away from your body to reduce the effect of shielding gamma radiation with your body. Turn the range-selector switch clockwise (from ‘X100’ to ‘X10’, then from ‘X10’ to ‘X1’, etc.) until you find the range position that results in the highest reading of the needle on the dial (not over 5). Pause a moment or two at each range position to see how fast the needle climbs.

2. With the range-selector switch in the ‘X0.1’ position, it will take 10-15 seconds for the needle to stop moving. It will take less time for the needle to reach a steady reading when the range selector switch is at the higher multipliers (‘X1’, ‘X10’, and ‘X100’). There are five numbers printed on the dial, starting with ‘0’ on the left and ending with ‘5’ on the right. Between each printed number and the next, there are ten divisions. The dial reading is obtained by writing down the number that appears nearest the needle on its left side, placing a decimal point to the right of that number, and then writing down the number corresponding to the number of the nearest division mark to which the needle points to the right of the printed number. For example, the dial reading in Figure 3-2, is 1.4. In Figure 3-3 the dial reading is 0.4, and in Figures 3-4 and 3-5 the dial readings are 4.1 and 2.5 respectively.

3. The radiation exposure rate is obtained by multiplying the dial reading by the number following the 'X’ at the position to which the range-selector switch points. For example, in Figure 3-2 the dial reading is 1.4 and the range-selector switch points to ‘X100’, so the radiation exposure rate is 1.4 X 100, or 140 roentgens per hour (R/hr). In Figure 3-3 the dial reading is 0.4 and the range selector switch points to ‘X10’, to the radiation exposure rate is 0.4 X 10, or 4 R/hr. Additional examples are shown in Figures 3-4 and 3-5.

4. When the dial reading is 0.5 or less, the range-selector switch should be switched one position clockwise to get a more accurate reading. In this position, where the switch points to a lower multiplier, the needle will move more for a given change in radiation rate, so you will be able to detect this change easier. For example, the range-selector switch in Figure 3-3 is set at ‘X10’ and the dial reading is only 0.4, for a radiation exposure rate of 4 R/hr. A more accurate reading of 4.1 R/hr is obtained for the same situation by switching the range-selector switch to ‘X1’ as shown in Figure 3-4, where the dial reading is 4.1

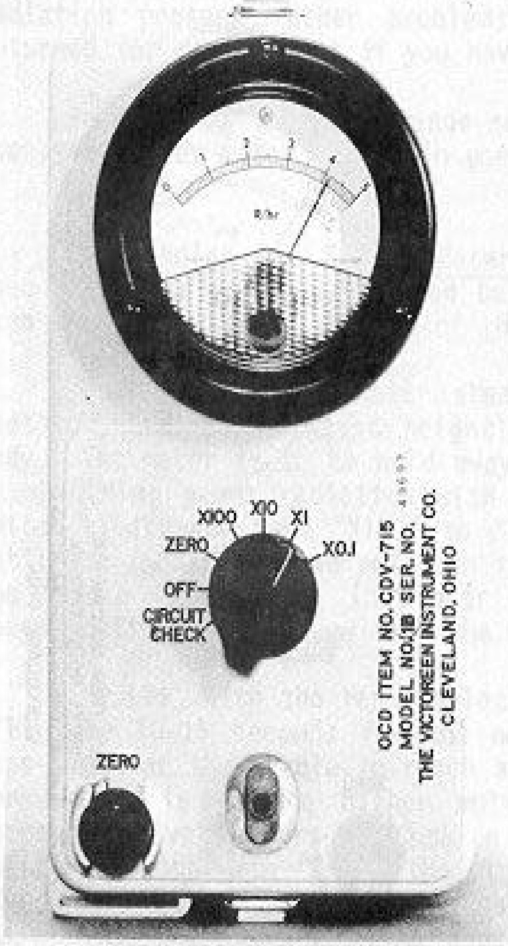


Figure 3-4. The survey meter dial reading is 4.1. This reading is multiplied by 1 to get the radiation exposure rate reading because the range-selector switch points to "X1." The radiation exposure rate is 4.1 R/hr.

(4.1 x 1 = 4.1)

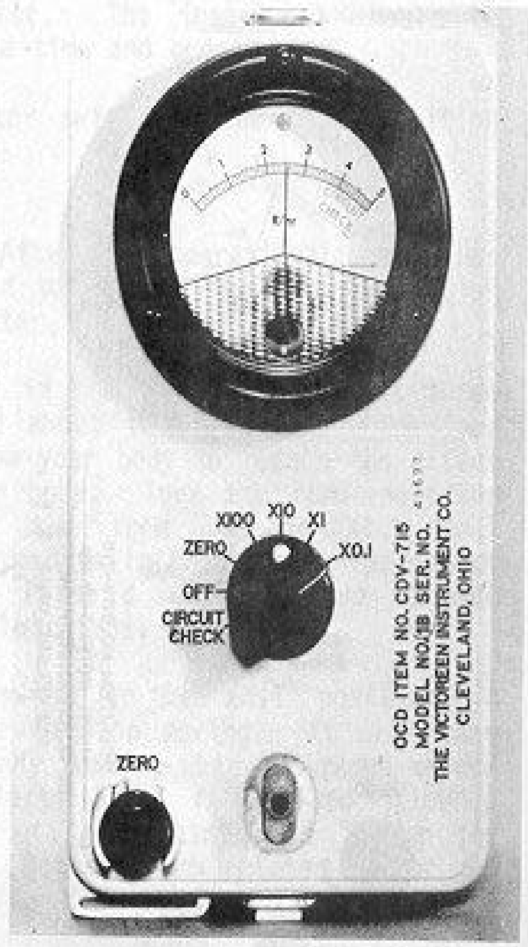


Figure 3-5. The survey meter dial reading is 2.5. This reading is multiplied by 0.1 to get the radiation exposure rate reading because the range-selector switch points to "X0.1." The radiation exposure rate is 0.25 R/hr.

(2.5 x 0.1 = 0.25)

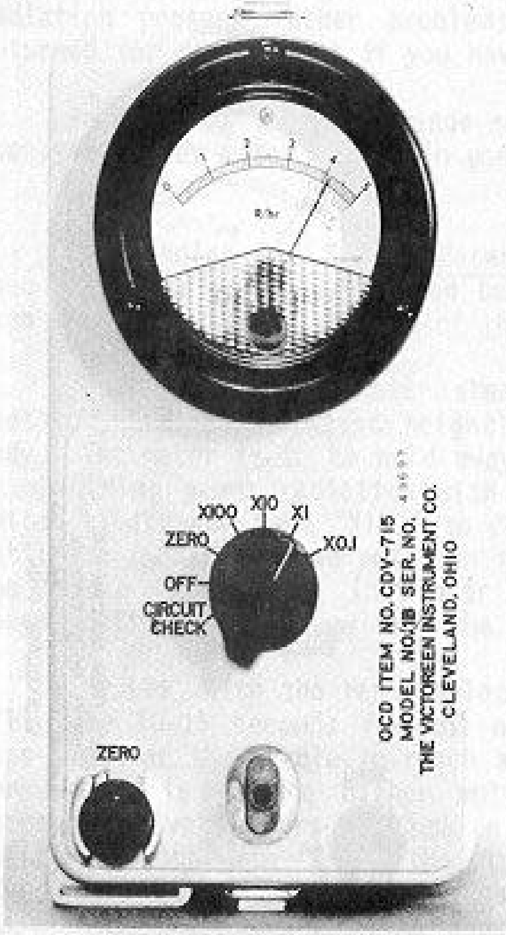


Figure 3-4. The survey meter dial reading is 4.1. This reading is multiplied by 1 to get the radiation exposure rate reading because the range-selector switch points to "X1." The radiation exposure rate is 4.1 R/hr.

(4.1 x 1 = 4.1)

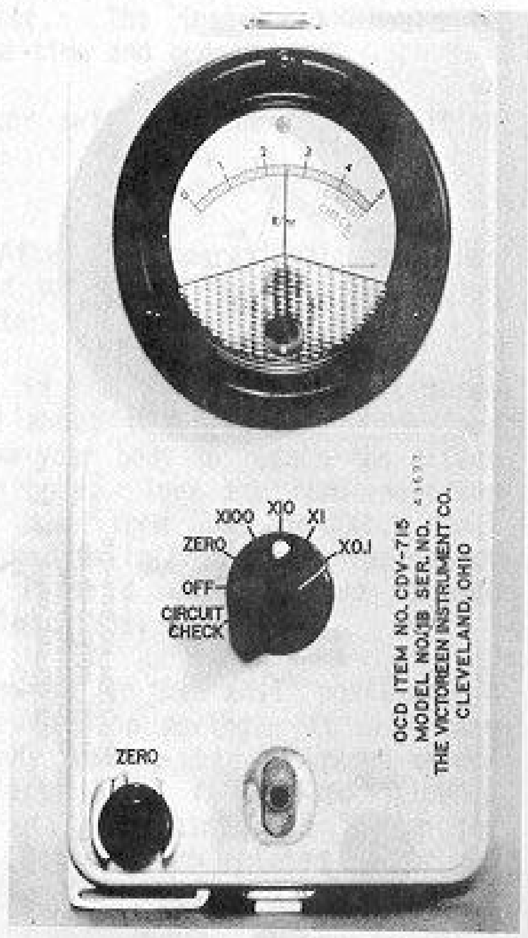


Figure 3-5. The survey meter dial reading is 2.5. This reading is multiplied by 0.1 to get the radiation exposure rate reading because the range-selector switch points to "X0.1." The radiation exposure rate is 0.25 R/hr.

(2.5 x 0.1 = 0.25)

5. If the needle climbs past 5, the range-selector switch should be switched to a higher range (counter-clockwise) until the needle remains on the scale.

e. **Troubleshooting the Survey Meter -** If you have trouble with the survey meter, it will probably be due to a poor battery, faulty battery installation, or poor battery contacts. Spare batteries should be kept in the shelter. With a good, new battery properly installed, the survey meter should have an operating life of about 200 hours under normal operating conditions. Dirty or corroded contacts can be cleaned with a pencil eraser, steel wool, or by very carefully scraping the contact surfaces with a knife. Bits of eraser, dirt, or steel wool must be very carefully and thoroughly removed from inside the case.

If radioactive dust gets on the outside of the survey meter, it should be carefully cleaned off with a cloth dampened in a mild soap solution. Instruments can be kept in a plastic bag to prevent contamination. If the inside of the meter accidentally becomes contaminated, the instrument should be taken to a clean area where the inside of the bottom case may be carefully cleaned off with a cloth dampened in a mild soap solution. It must be THOROUGHLY DRIED before putting the case together. The electronic components mounted on the inside of the top cover may be brushed and dusted off with a dry brush and/or blown out with dry air. A damp cloth should NOT be used on any of the electronic components. If the remaining interior contamination causes a slightly increased reading only on the ‘X0.1’ range, the instrument will still be useful.
Do not try to make any calibration adjustments or any repairs on the survey meter. Special equipment and specially trained people are necessary to do these jobs.

3-3. **Preparation for using the Dosimeter Charger**

a. **Preliminary -** The dosimeter charger (Figure 2-3) is necessary to move the hairline on the dosimeter back to the starting (zero) position, as described briefly in paragraph 2-5. Without a dosimeter charger, the dosimeter can’t be used after the hairline has reached the end of the scale. Because the dosimeter charger is necessary to use the dosimeter, preparation of the charger is described first.

The charger has one control knob, called the voltage control. When the charger is turned so the printing on the top can be read, this knob is located on the top, far-right corner of the charger. On the top left corner there is a cap with a chain coming out of the top of it; beneath this cap is the charging contact. The chain keeps the cap from getting lost when it is unscrewed and lifted off the charging contact. The cap should be kept screwed down over the charging contact when the charger is not in us, to keep the contact clean, to prevent mechanical damage, and to prevent accidental discharge of the battery.

b. **Installing the battery in the Charger -** The charger is powered with a single D-Cell flashlight battery. The battery powers two things in the charger: the electronic circuit that charges the dosimeter and the light bulb that illuminates the dosimeter scale while charging it.
CAUTION: THE CHARGER SHOULD NOT BE USED AS A FLASHLIGHT. Using the charger as a flashlight will quickly run down the battery and then, unless you have spare batteries, you won’t be able to charge the dosimeters. The battery should be removed if the charger will not be used for a few days or longer.

Figure 3-6. A coin may be used to open the dosimeter charger to put in a battery.

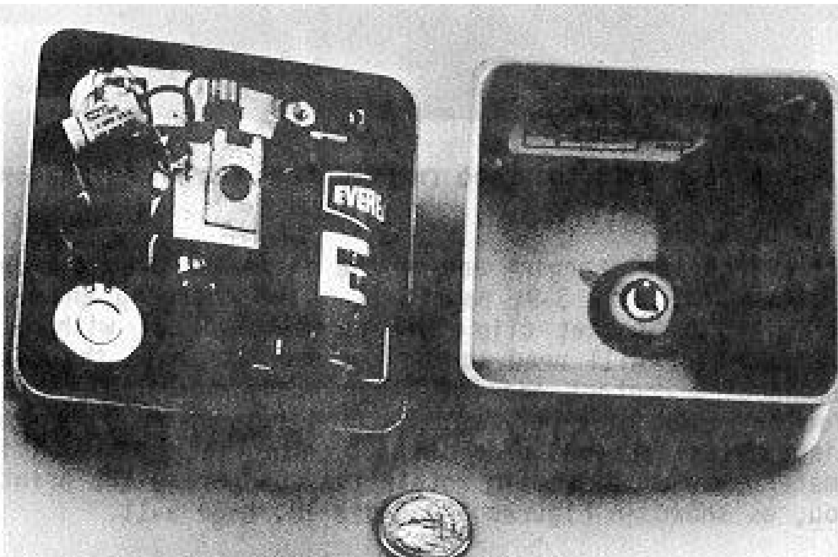


Figure 3-7. The interior of a dosimeter charger with battery in place in the inside top cover. The bulb which lights to view the dosimeter is at the upper left, and an extra bulb is mounted just to the left of the battery.

The battery is installed as follows:

1. Use a coin or screwdriver to unscrew the large screw at the center of the bottom* of the charger, as shown in figure 3-6. [*On some models the screw head is on the top.] After a few turns counter clockwise, you will feel that the bottom of the charger case is no longer attached to the top. The screw will not come out and remains attached to its part of the case.

2. Lift the bottom case (which is now on top) up from the top part.

3. Install the D-cell battery in the rectangular battery holder mounted on the inside of the top cover. The insides of a charger are shown in Figure 3-7, with the battery inserted in the top part shown at the left. If you have trouble deciding how the battery should be put in, read paragraph 3-2b(4).

4. Notice the rubber pad glued to the inside floor of the bottom. (The rubber pad may not be in some chargers). Place the bottom part of the case over the top so the rubber pad is over the battery, and tighten the screw by turning it clockwise.

c. **Checking the battery and the Dosimeter Charger (Operational Check) -** This procedure is also used for resetting or zeroing a dosimeter. A dosimeter is needed for a full operational check of the charger.

CAUTION: If the dosimeter has been in use to measure radiation dose, you should write down its reading (see paragraph 3-4d) before using it to check the charger. Otherwise, if the charger bulb doesn't light up, you may accidentally push the dosimeter down too far when you reach step (40 below and change the dosimeter reading. There are two levels of pressure which you will feel as you push the dosimeter down on the charging contact switch. One level, at fairly light pressure, turns on the lamp. The second level, at higher pressure, charges the dosimeter.

The Operational Check is Made As Follows:
1. Put the charger on a firm, flat surface such as a table, desktop, or floor.
2. Unscrew the cap from the charging contact and lay it to one side, as shown in Figure 3-8.

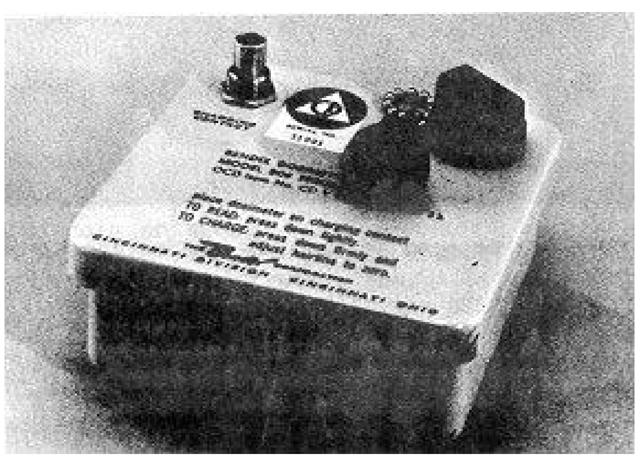


Figure 3-8. The charger with the knob removed from the charging contact.

3. Place the charging end of the dosimeter over the charging contact, as shown in figure 3-9. The charging end is opposite the end with the pocket clip and is hollowed out with a center post down inside. You will need to use one hand to hold the dosimeter down on the charging contact and the other hand to adjust the voltage control. You may need to experiment to find out which arrangement of your hands is easiest for you to do the job. If the right hand is used on the dosimeter, you will need to rotate the charger so the printing is awaqy from you, as shown in Figures 3-9 and 3-10.

4. Look through the dosimeter eyepiece on the end by the pocket clip, and push the dosimeter down gently on the charging contact against the spring pressure until you can see the dosimeter scale light up. If the charger light doesn't come on, check the battery, light bulb, and contacts as described in paragraph 3-3d, 'Troubleshooting the Dosimeter Charger'.

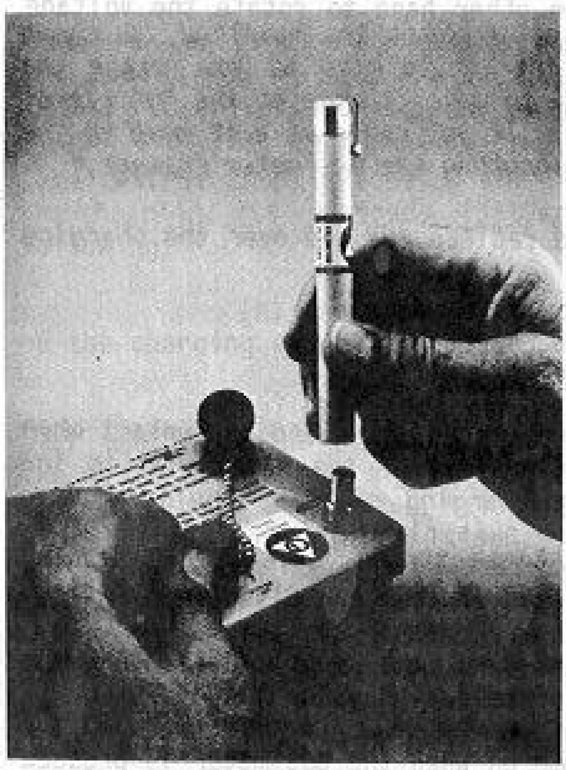


Figure 3-9. Placing a dosimeter on the charger.

Figure 3-10. Resetting a dosimeter to "zero" with a dosimeter charger.

5. Push down the dosimeter with greater pressure on the charging contact until it reaches bottom and won't go any further. Hold it there.

6. While the dosimeter is being held solidly down on the charging contact with one hand, use the other hand to rotate the voltage control knob. Look through the eyepiece to watch the hairline, as shown in Figure 3-10. The hairline should move as you rotate the voltage control, and you should

be able to make it move to the ‘0’ (zero) at the left end of the dosimeter scale. If you can’t make it move to the zero, check the next section, ‘Troubleshooting the Dosimeter Charger’.

7. Remove the dosimeter and replace the cap over the charging contact.

d. **Troubleshooting the Dosimeter Charger**

1. Always keep the protective cap on the charging contact when the charger is not in use. The smooth surface of the clear plastic insulator around the center post of the charging contact should be dry, clean, and without fingerprints. Use a soft cloth (free of grit, dirt, lint, and moisture) to clean it. Don’t use strong solvents or cleaning fluids to clean plastic parts because some of them can dissolve plastic.

2. Take out the battery and keep the case closed when the charger is not to be used for periods of several days or longer.

3. If the light does not come on when the dosimeter is pressed down on the charging contact, do the following:
a. Check the battery to be sure that it is installed with the correct polarity (in the right direction) and that it is making good electrical contact. If the condition of the battery is questionable, replace it with a battery that is known to be good.
b. Check the light bulb to see if it is loose in the socket (see Figure 3-6), and tighten if necessary.
c. Replace the bulb with the spare if there is any chance that the bulb is burned out.
d. After taking the above actions, if the light still does not come on when the charging contact is depressed, the charger should be returned for repair or replacement, if possible.

4. If the light is dim or appears weak, do the following:
a. Check the battery to make sure that good electrical contact is being made.
b. Clean the battery and light switch contacts with a pencil eraser or steel wool until the metal making contact is bright and shiny.
c. Tighten the nut on the charging contact.
d. If the condition of the battery is questionable, replace it with a battery that is known to be good.

5. If the dosimeter scale is illuminated, but when the voltage control knob is rotated the hairline does not appear on scale, or the hairline is unsteady (jittery movement of the image), do the following:
a. Check for dirt or moisture on the charging contact or on the charging end of the dosimeter, and clean it off.
b. Check for good electrical contact between the dosimeter and the outer aluminum sleeve of the charging receptacle. Press the dosimeter down firmly against the charging receptacle and rotate the dosimeter back and forth a half-dozen times. Keeping the dosimeter vertical, move the dosimeter sideways to make the charging contact sleeve touch the inside wall of the dosimeter charging receptacle.
c. Check for proper electrical contact between the light switch spring contacts, and clean them if necessary (see above).
d. Try another dosimeter.
e. If the hairline image still cannot be made to appear on the scale after takiing the above actions, the charger should be returned for repair if possible.

3-4 **Preparation for using the Dosimeter**

a. **Preliminary -** What the dosimeter measures and how it works are briefly described in paragraph 2-4. The dosimeter (Figure 2-2), has no battery to install and run down and no controls to operate. As long as the hairline is on the scale when viewed through the eyepiece, the dosimeter can be considered to be turned on. It actually operates continuously. The position of the hairline on the scale can be read anytime and as often as you wish. If the hairline can't be seen, then the dosimeter is useless and must be recharged.

b. **Charging or Zeroing the Dosimeter -** An electric charge must be placed inside the dosimeter to make the hairline visible and to reset it to the zero position on the scale. A dosimeter charger is necessary for this operation. Exactly the same procedure is used to zer4o or reset the hairline of the dosimeter as is used for the operational check of the dosimeter charger.

In a fallout situation, be sure to write down the reading on the dosimeter scale, as well as the time, just before the dosimeter is charged or reset to zero. The reason for keeping such records and how to do it are described in paragraph 4-4f. "Keeping Track of Everyone's Radiation Exposure." If you use the charger to read the dosimeter, be careful not to press the dosimeter down too hard on the charging contact or else you will wipe out the reading. Because of this possibility, you may wish to use another light source for reading (when not zeroing) the dosimeter.

The dosimeter is zeroed as follows:

1. Put the charger on a firm, flat surface such as a table, desk top, or floor.

2. Unscrew the cap from the charging contact and lay it to one side, as shown in Figure 3-8.

3. Place the charging end of a dosimeter over the charging contact, as shown in Figure 3-9. The charging end is opposite the end with the pocket clip and is hollowed out with a center post down inside. Use one hand to hold the dosimeter down on the charging contact and the other hand to adjust the voltage control. You may need to experiment to find out which arrangement of your hands is easiest for you to do the job. If the right hand is used on the dosimeter, you will need to rotate the charger so that printing is away from you, as shown in Figure 3-9 and 3-10.

4. Look through the dosimeter eyepiece on the end by the pocket clip, and push the dosimeter down gently on the charging contact against the spring pressure until you can see the dosimeter scale light up. If the charger light doesn't come on, check the battery, light bulb, and contactws as described in paragraph 3-3d, "Troubleshooting the Dosimeter Charger."

5. Push the dosimeter with greater pressure down on the charging contact until it reaches bottom and won't go any farther. Hold it there.

6. While the dosimeter is being held solidly down on the charging contact with one hand, use the other hand to rotate the voltage control knob, and look through the eyepi3ece to watch the hairline, as shown in Figure 3-10. The hairline should move as you rotate the voltage control, and you should be able to make it move to the '0' (zero) at the left end of the dosimeter scale. If yu can't make it move to the zero, check paragraph 3-3d, "Troubleshooting the Doisimeter Charger."

7. After you have zeroed the hairline, lift the dosimeter from the CHARGING POSITION (which is all the way down) to the VIEWING POSITION (which is almost all the way up), and check the

position of the hairline. It may have drifted to one side or the other of the zero, and you will need to zero it again. After a little practice, you will be able to zero the hairline quickly in one try.

8. Remove the dosimeter and replace the cap over the charging contact of the charger.

c. **Checking Dosimeters for leaks -** Dosimeters are very reliable and rugged, but there may occasionally be one which may 'leak'…that is, the hairline will slowly drift up-scale to the right of zero, even though there may not be enough radiation around to make the needle move at all in a non-leaking unit. Most of the leaking dosimeters should have been weeded out or repaired while they were in storage, but there remains a small chance that you may have a leaking dosimeter in your shelter. If there is time during a crisis period before a nuclear attack, check your dosimeters for leakage as follows:

1. Zero all dosimeters. Record their serial numbers and the time they are zeroed.

2. Place the dosimeters in a secure place.

3. Check each dosimeter and record the readings every 12 hours. You may wish to check them in a shorter time if you think a nuclear attack may happen at any moment. Do not wait until after a nuclear attack has begun to check the dosimeters for leakage. Record the readings and the time even though you check the dosimeters in the intervals of less than 12 hours. If a nuclear attack doesn't begin, continue to check the dosimeters for four days (96 hours).

4. At the end of the leak-checking period, whether four days or less (depending on the situation), calculate the leakage per 24-hr day for each dosimeter. For this calculation, use the final reading on the dosimeter at the end of the leak-checking period. Ignore dosimeter readings taken at other times during the leak-checking period. Multiply this FINAL reading by 24 and then divide by the total number of HOURS in the leak-checking period.* [This calculation can be more directly specified by a formula as follows: Let R represent the reading of the dosimeter at the end of the leak-checking period, and let T represent the total number of HOURS in the leak-checking period. The leakage rate per day in Roentgens per day, represented by L, is calculated from the formula: L = 24 R/T (The slash, '/' means that the product, 24R, is divided by T].

For example, if you estimate the dosimeter reading to be 2R (2 roentgens) after a leak-checking period of 8 hours, the leakage rate, L, is L = (24 X 2) divided by 8 = 6R/day.

If a dosimeter leaks as badly as the dosimeter in this example, it can still be used, but you must calculate the leakage and subtract it from the dosimeter reading to get a correct radiation exposure reading. If there is not time or opportunity during a crisis period to exchange dosimeters that leak more than 2-3R per day, they should be marked with an 'L' on the body of the dosimeter, either with paint or fingernail polish, if available, or by scratching in the enamel of the dosimeter with a knife or sharp instrument. A label could be attached which shows the leakage rate. The mark or label will alert the person reading the dosimeter not to become unduly alarmed at a high reading on the dosimeter. If the dosimeter leakage is greater than 10R per day, it should be considered to be unreliable.

d. **Reading the Dosimeter -** Reading a dosimeter has been discussed in paragraph 2-4, "The Dosimeter," and in paragraph 3-4b, "Charging or Zeroing the Dosimeter." Some additional information will be given in this section.

When you point a dosimeter to a light and look through the eyepiece with your eye about _ inch from the lens, you should see a field of view as illustrated in Figure 3-11. You may need to rotate the dosimeter so the word 'ROENTGENS' appears right side up. The hairline is at zero in this illustration, where it should be placed whenever the dosimeter is recharged. In Figure 3-12, the hairline is at about 107 R. If you read the dosimeter with the scale running up and down instead of horizontally, you will get a reading which is slightly wrong, due to the effect of gravity.

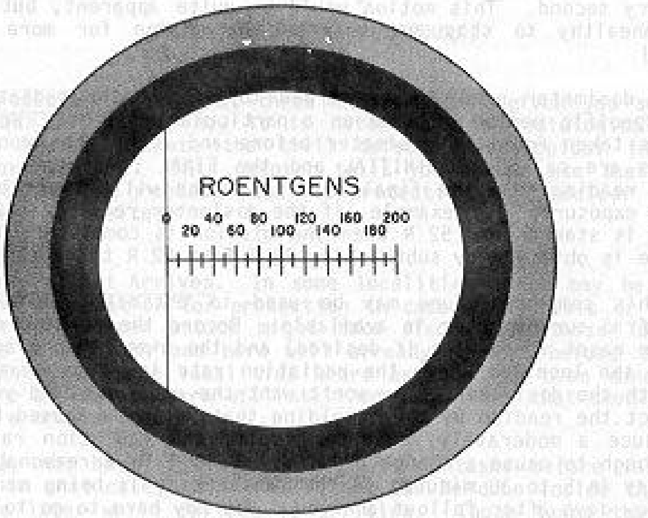


Figure 3-11. Field of view of dosimeter with hairline set at zero.

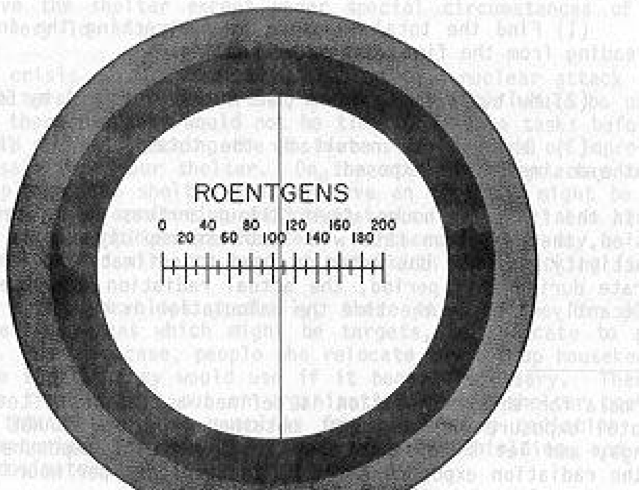


Figure 3-12. Field of view seen in a dosimeter with hairline at about 107 R.

The reading of the location of the hairline on the center scale can be estimated to the nearest whole number. For various reasons you may wish to record the dosimeter reading to the nearest whole number, although the accuracy of the instrument is rated at within plus or minus 20 percent when measuring gamma radiation from fallout. This accuracy specification means that if the actual exposure is 107 R, then the dosimeter should read between 86 R and 128 R. There are a couple of reasons for reading and recording the dosimeter to the nearest whole number. In principle, the dosimeter could be calibrated at a later date, if necessary, and the recorded readings might be corrected to a more accurate value. Another reason for recording the reading to the nearest whole number is that you may be interested in seeing small increases in the radiation exposure, from 18 R to 20 R, for example.

You need a light source to read the dosimeter. A match, a candle, or a flashlight will do. However, the brighter the light, within reason (the sun is TOO bright), the easier it is to see the scale and the hairline. The dosimeter charger has a built-in light for reading the dosimeter, but the charger must be used with CAUTION. If the dosimeter is pressed down too hard on the charging contact, the dosimeter reading will be lost. Also, use of the charger light will run down the battery unnecessarily if other light sources are available.

When gamma radiation is present, the hairline of the dosimeter is moving all the time, usually so slowly that the motion can't be seen. If the radiation exposure rate is very high, the movement will become visible. For example, if the radiation exposure rate is 7200 R/hr, the hairline of the dosimeter would march across the scale at the rate of 2 R every second. This motion would be quite apparent, but it would be very unhealthy to stay and observe the motion for more than a few seconds!

A dosimeter need not be zeroed to measure the radiatio0n exposure for a specific period of time or a particular mission. Write down the readings taken from the dosimeter before and after the exposure. These readings are called the INITIAL and the FINAL readings. Subtract the initial reading from the final reading (which will always be larger) to get the exposure. For example, if the dosimeter reading is 28 R when the mission is started and 52 R when the mission is completed, the radiation exposure is obtained by subtracting 28R from 52 R to get 24 R.

This same procedure may be used to estimate radiation exposure RATES if no survey meter is available. Record the reading on the dosimeter (or reset it to zero if desired) and the time, then place the dosimeter in the location where the radiation rate is to be measured. Don't stay with the dosimeter. You won't want the exposure, and you won't want to affect the reading by the shielding that would be caused by your body. To produce a moderately accurate result, the radiation rate should be high enough to cause a change of at least 10 R in a reasonable period of time, say in 5 to 30 minutes if the measurement is being made during the first few days after fallout arrives. You may have to go to the location and read the dosimeter a few times before it shows a suitable change. When the dosimeter reading shows an increase of at least 10 R, record the new reading and the time, and remove the dosimeter from the location. Calculate the radiation exposure rate in roentgens per hour as follows:*

1. Find the total exposure by subtracting the initial dosimeter reading from the final dosimeter reading.

2. Multiply this number (the total exposure) by 60.

3. Divide your result by the total time in MINUTES during which the dosimeter was exposed.

In the first few hours after fallout arrives at a location near the explosion, the radiation rate will decrease rapidly due to the decay of radioactivity. If the dosimeter is used to estimate the radiation exposure rate during this period, the actual radiation exposure rate may be significantly lower by the time the calculation is made.

*A formula for this calculation is defined as follows: Let D represent the total exposure in roentgens, obtained from the CHANGE in dosimeter readings, and let T represent the total time of exposure in minutes. Then the radiation exposure rate, R, in roentgens per hour is calculated for the formula: R = 60 D/T

Chapter 4
RADIATION SAFETY PROCEDURES

4-1. **Introduction -** The first three chapters have given you some facts about nuclear radiation, how it is detected with radiological instruments, and how to operate the civil defense radiological instruments provided for shelters. This chapter tells you how to use that information to provide the greatest possible protection from nuclear radiation while you are in shelter.

4-2**. Before Fallout Arrives -** In some localities there may be detailed planning and preparation for protection in case of a crisis or emergency during which a nuclear attack might take place. In those localities, many of the tasks described here will already be done before the crisis happens. Even in those localities where as much has been done as possible before a crisis, there will still be some tasks that should be done soon after a crisis occurs.

It may not be possible to do all these tasks before fallout arrives, and in that case, those tasks that can be done inside the shelter can be done later while fallout is arriving. Those tasks that require trips outside the shelter will have to be postponed or forgotten if they are not completed by the time fallout begins to arrive, unless special circumstances of extreme urgency or very low risk make the trips worthwhile. No one who is in a shelter when fallout begins to arrive should leave the shelter except under special circumstances of extreme urgency or very low risk.

If a crisis develops quickly, leading to a nuclear attack on short notice, shelters in the communities where people live would be used. In this case, there probably would not be time to do some tasks before fallout arrives, such as checking the dosimeters for leakage or improving the radiation safety of your shelter. On the other hand, you may know many of the people in the shelter and may have an idea who might be able to help with radiation monitoring and other tasks. You may also know where useful and vital supplies are located. Furthermore, you may be familiar with the shelter and will not need to spend much time checking it out.

If a crisis develops gradually, there may be time for people in high-risk areas, areas which might be targets, to relocate to areas of lower risk. In this case, people who relocate may set up housekeeping in or near the shelter they would use if it became necessary. There would probably be time to work out an organization of the shelter population, check out the shelter, get supplies for maintaining radiation records, stockpile materials for possible use as emergency shielding, and to leak-check the dosimeters.

A discussion of things to do for radiation safety before fallout arrives is given in paragraphs 4-2a through 4-2d. Two checklists for the RM, (Radiological Monitor) are provided at the beginning of this handbook: Checklist ‘A’ for immediate action, and Checklist ‘B’, a standard checklist for RM’s.

RADIATION EXPOSURE RECORD

Name ______________________

Home Address ______________________

Social Security No. ______________________

Shelter Address ______________________

____

Name of Shelter
Unit Leader ______________________

Rad. Sensitivity
Category ______________________

Hour and Date	Added Exposure (R)	Total Exposure To Date	Comments

FRONT SIDE

Hour and Date	Added Exposure (R)	Total Exposure To Date	Comments

BACK SIDE

Figure 4-1. Front and back side of a form for keeping track of the individual's nuclear radiation exposure.

a. **Organization of the Shelter Population -** The Shelter Manager and assistants will supervise the organization of the shelter population into small groups called shelter units. Organization of the shelter population into shelter units, each with its own Unit Leader, is necessary not only for good management but also for keeping a radiation exposure record for each person in the shelter. There may be between seven and fifteen people in a shelter unit. There probably won't be enough dosimeters for each person to have one. The shelter Unit Leaders can help estimate the radiation exposure of those people in their units who don't have dosimeters. The Unit Leaders can also see that someone fills out the radiation exposure record for those who are unable to do it for themselves, such as small children.

Organization of the shelter population into shelter units will also be nece3ssary in case people need to be moved to a different location in the shelter where the exposure rates are lower. Unit Leaders can supervise the movement to see that their units move as a group and that no one accidentally moves into a hazardous area.

After the shelter units have been organized and the Unit Leaders selected, the Unit Leaders should be shown how to fill out the radiation exposure records. If blank forms (see Figure 4-1) are available, these should be issued before fallout arrives. The Unit Leader should see that the top part of each form is filled out for everyone in the unit.

Radiation sensitivity categories are listed and described in Table 4-1. Identifying people according to these categories before fallout arrives may be useful if it should later become necessary to arrange3 for special shielding. The effect of a given whole-body exposure to radiation will vary somewhat among individuals, due partly to age, sex, body thickness, and general health. The sick, aged, and very young are the most susceptible. Nevertheless, it is generally advisable for shelter management to consider the entire shelter population to be equally susceptible to the effects of radiation, with the possible exception that children and pregnant women should be treated as being more susceptible. If a woman is pregnant, her radiation exposure record form should be marked 'PG' on the line following 'Rad. Sensitivity Category'.

Table 4-1. Radiation Sensitivity Categories

Category	Description	Cause for Immediate Concern
PG	Pregnant Women	Miscarriages, malformed babies, radiation sickness.
Child	Infants, children	More susceptible to radiation injury than adults.
Y/A	Youths and Adults	Radiation sickness.

In addition to radiation sickness, there may be radiation effects that occur many months or years after exposure such as cancer, leukemia, sterility, cataracts, and genetic injury. The probability of developing such late effects should not be a principal determining factor in decision-making during a nuclear war emergency, but such effects can and should be minimized by keeping controllable exposures as low as possible.

b. **Checking Out the Shelter -** Many different kinds of shelter will be used for protection against fallout in an emergency. Some shelters may be in schools, churches or banks. Others may be in factories, office buildings, large stores, underground garages, basements of apartments or houses, mines or caves. Some shelters may have many rooms, some of them on different levels, and others may have just one large room. The problems of providing the best radiation safety will be a little different in each shelter.

The Emergency Operating Center (EOC) should be consulted if special problems, not discussed in this handbook, should arise. Finding a solution for some of these problems may mean the difference between life and death for some of the people in your shelter. These solutions may depend on how good you are at inventing and putting together ideas on the spot and being able to do things in a difficult situation.

Here is a list of items to check out and do in your shelter before fallout arrives. In the sections following the list, each item is discussed in greater detail. The most urgent items are included in Checklist ‘A’ for immediate action. All of the items are included in Checklist ‘B’, the standard checklist for RM’s. You, the RM, will have to work in cooperation with the Shelter Manager and others on many of these items.

- Which locations appear to offer best protection against fallout? Sketch a shelter floor plan and mark these locations.

- Is there going to be enough room for all of the people in the location of best protection?

- Can the radiation safety of the shelter be improved with tools, materials, and manpower on hand?

- Are there openings to be baffled or covered to reduce the amount of radiation coming through? Will these changes allow enough air to flow through to keep people from getting too hot when they are crowded?

- Are materials and tools handy which could be used for putting up additional, improvised shielding inside the shelter after fallout arrives?

- Is there going to be a problem if a lot of people enter the shelter while fallout is coming down? Are brooms and dustpans on hand to sweep up fallout particles?

- Will trips for water or to restrooms increase radiation exposure?

- Where could dosimeters be mounted or hung? Are needed materials available for mounting or hanging them?

- Where can instruments, instrument supplies, flashlights and other light sources so you can move around and read instruments if the power goes out?

- Are writing supplies available, including pens or pencils, and printed forms or paper, for keeping records of radiation exposure? Do you have a notebook in which to keep a record (RM log) of events?

1. **Best Protection -** Which locations appear to offer the best protection against fallout? Sketch a shelter floor plan and mark these locations.

The best protection is provided, by getting as much mass as possible between you and the fallout. Walk through the shelter and get an idea where the best protected areas might be. Usually, but not always, the areas having the least amount of daylight reaching them will provide the best protection.

Basements provide good protection from the sides if they are well below ground and there is earth all around, but they may not always provide good protection from ‘skyshine’ or from radiation from fallout that has settled above the basement or on neighboring rooftops. If the floors above the shelter are made of solid concrete, they will be much more massive than floors of wood and will provide much better protection from overhead gamma radiation. Similarly, walls of solid brick or concrete will provide better protection than walls of hollow concrete or cinder-block; these walls, in turn, will provide better protection than walls of gypsum board or plywood.

Tall buildings can provide good protection from gamma radiation in the inner rooms of floors that are at least four stories above the ground or surrounding rooftops. There should be at least three stories above the shelter to provide protection from fallout on the roof. These locations do not provide blast protection and should not be used in areas less than 25 miles from a likely target for a nuclear weapon.

If we expect the gamma radiation from fallout to be reduced at a certain location by a factor of four from what the radiation level would be outside above a very large, flat, smooth, open area, covered with the same kind and amount of fallout, we say the FALLOUT PROTECTION FACTOR (FPF) of that location is four. This factor is also called the PROTECTION FACTOR (PF).Some locations that are rated with a high protection factor, such as shelters in the upper levels of a skyscraper, may provide little protection against other nuclear weapons effects such as blast. A high PF for a shelter location only indicates good protection against gamma radiation from fallout. Such a shelter location may also, but not necessar9ly provide protection against other nuclear weapons effects. We will use the term FPF in this handbook instead of PF to indicate the protection provided by a shelter location against gamma radiation from fallout.

Some FPFs that might be possible in different locations in buildings are shown in Figure 4-2.

The Shelter Manager may have a sketch of the shelter floor plan or may make arrangements to have one drawn. The sketch should show roughly how the rooms are arranged, the approximate sizes of the rooms, where windows and doors are located, and if possible, what kinds of materials are used to make the walls. You will use this sketch to keep track of your radiation measurements at different locations, where most of the people are located at different times, and where you might have to construct special shielding. You might ask someone in the shelter to draw or trace several copies for you so you will have a copy for each set of information, circumstances or instructions.

A sample sketch of a basement of an apartment building is shown in Figure 4-3. We will call this make-believe building Erskine Hall, and we will use it for several examples.

The side view is included because it shows how deep the basement sits in the ground and that the ceiling is a concrete slab which provides good shielding against gamma radiation. It is not always necessary to sketch a side view, but you might want to include one to show a particular feature of the shelter.

The sketch in Figure 4-3, shows the location of four drainpipes from roof gutters. If there were moderate to heavy rainfall after fallout, there could be pileups of fallout by the drainpipes that could increase the gamma radiation along the walls on the inside of the shelter opposite the drainpipes.

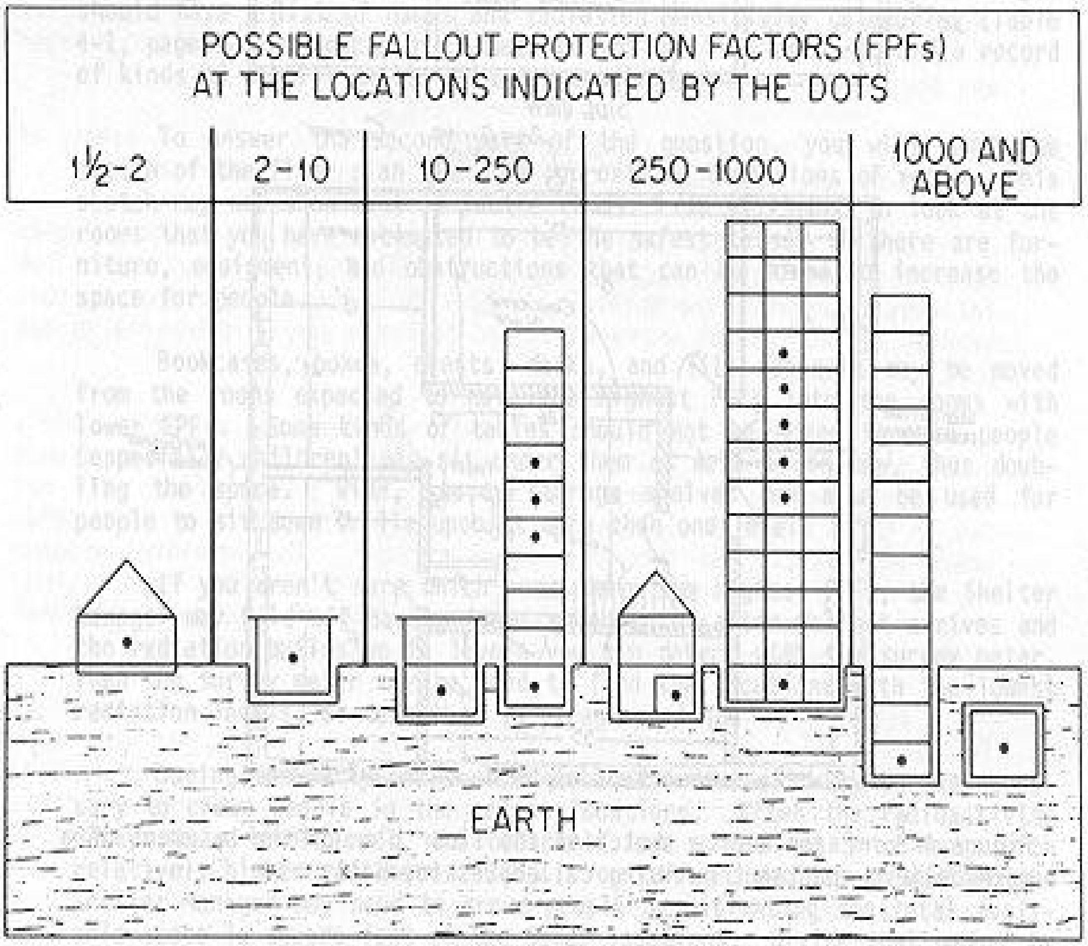


Figure 4-2. Deep basements and buried shelters have high FPFs (1000 and above). They provide good protection against gamma radiation from fallout. Tall buildings also provide good protection against gamma radiation from fallout in the locations indicated by dots in the drawing, but they provide little protection against blast. The FPFs indicated above are for isolated buildings. The FPFs would be higher for ground-level and below-ground shelters that are surrounded or partly surrounded by buildings. The first floors of houses and partially buried basements have low FPFs and provide little protection against gamma radiation from fallout.

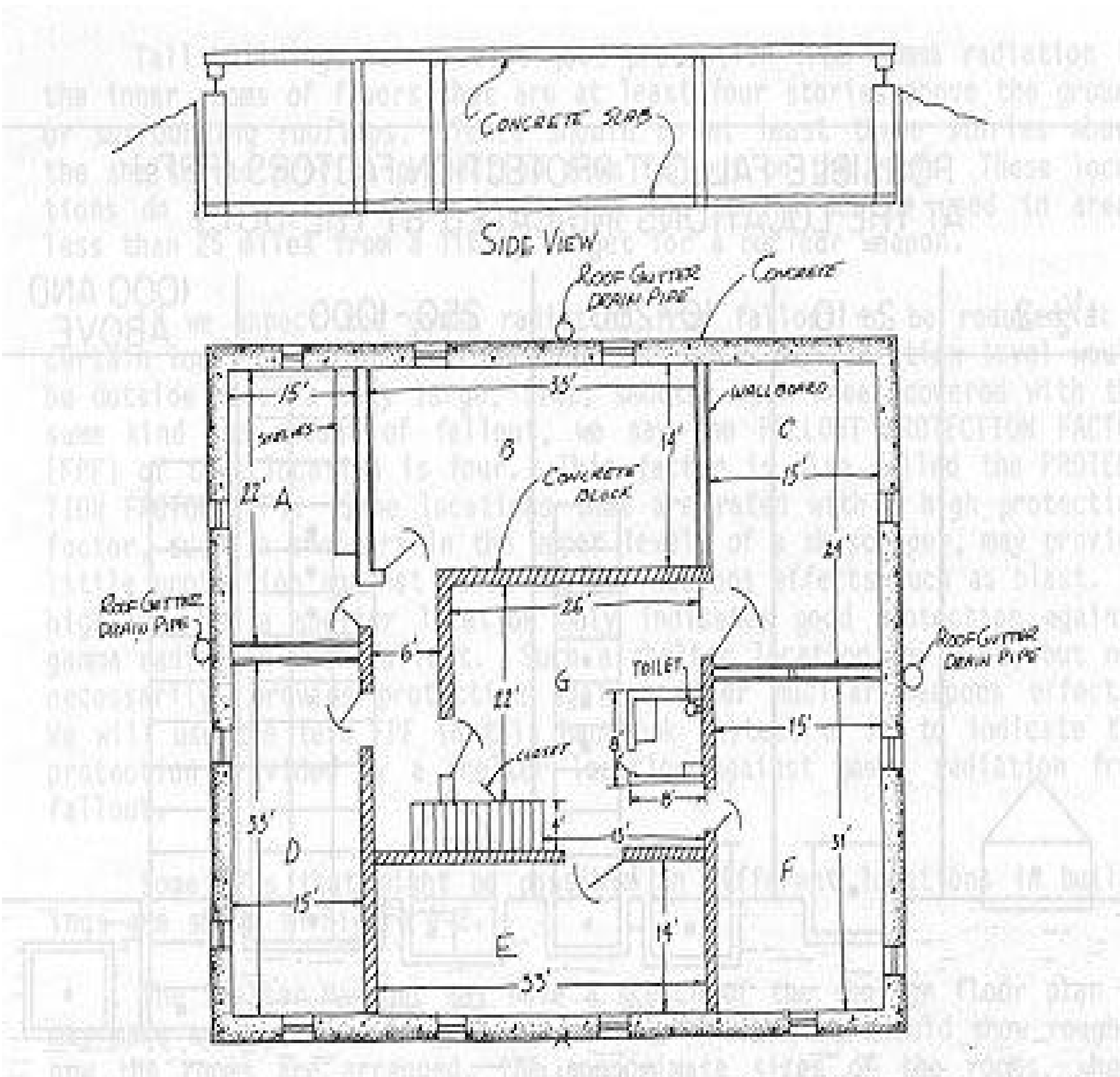


Figure 4-3. Example of a sketch of the floor plan of the basement of a make-believe apartment building called Erskine Hall.

Two kinds of interior wall construction are indicated in the sketch in Figure 3-4, concrete block and wallboard, probably gypsum. The rooms have been named with letters of the alphabet. Room ‘G’ looks like it would provide the highest FPFs because it is surrounded by outside rooms and has walls of concrete block.

2. **Space -** Is there going to be enough room for all of the people at this shelter in the locations of best protection?

After the locations have been found that appear to provide the best protection, you should talk with the Shelter Manager about the problem of having enough room. To answer this question, you will need to know two things: (a) how many people are in or assigned to your shelter and (b) how much space is available in the locations of best protection.

The Shelter Manager should be able to tell you how many people are already in the shelter or are assigned to it. The Shelter Manager should have a list of names and radiation sensitivity categories (Table 4-1) of occupants, names of shelter Unit Leaders, and a record of kinds of special skills that are available amongst those in the shelter.

To answer the second part of the question, you will need the sketch of the floor plan with the approximate dimensions of rooms. This sketch may not show what is in the rooms. You will need to look at the rooms that you have estimated to be the safest to see if there are furniture, equipment, and obstructions that can be moved to increase the space for people.

Bookcases, boxes, chests, desks, and file cabinets may be moved from the rooms expected to have the highest FPFs into the rooms with lower FPFs. Some kinds of tables should not be moved because people (especially children) may sit under them as well as on top, thus doubling the space. Wide, sturdy storage shelves can also be used for people to sit down or lie upon at more than one level.

If you aren't sure which rooms have the highest FPFs, the Shelter Manager may hold off having items moved until after fallout arrives and the radiation builds up to levels you can detect with the survey meter. Then the survey meter may be used to find the locations with the lowest radiation levels, as described in paragraph 4-4b.

During the early hours after fallout arrives, it may become necessary to crowd people in the safest locations. After the radioactivity decays to a lower level, the occupants can spread out into rooms with relatively higher radiation levels. You can get an idea of whether the Shelter Manager may need to crowd people by estimating the total available space in square feet of the safer locations. Divide that number by 10, the number of square feet allowed per person. If the resulting number is larger than the number of shelter occupants, you have plenty of space in the safer locations. If the number is smaller than the number of shelter occupants, it may be necessary to crowd people temporarily in the safer locations. The number of people in the safer locations can be doubled if you crowd them TEMPORARILY by squeezing down the space per person from 10 square feet to five square feet.

In the sketch shown in Figure 4-3, the available floor space in Room G, including the toilet, is about 624 sq. ft. The hallway to the left of Room G adds about 132 sq. ft. for a total of 756 sq. ft. in the estimated safer locations. Divide 756 by 10, and round off to 76. If more than 76 people are assigned to the apartment building basement in Figure 4-3, they will need to be crowded in Room G and the hallway if the radiation builds up to hazardous levels after fallout arrives. With maximum crowding, they could squeeze about 152 people into Room G and the hallway during the most hazardous times. If more than 152 people were assigned to this shelter, some of them would have to be sheltered in the outer rooms, which are not as safe. In that case, they might work out a rotation scheme so people would share, as fairly as possible, the higher radiation exposures of the outer rooms.

If it is necessary to crowd people in the safer locations, it is very important that enough fresh air and light are provided so that people don't pass out from heat prostration or get claustrophobia (fear of confined, crowded places) and run outside. Both the Shelter Manager and the RM will be involved in these problems.

3. **Radiation Safety Improvement -** Can the radiation safety of the shelter be improved with tools, materials or the manpower on hand?

As you go through your shelter looking for the places that appear to provide the best shielding from gamma radiation, you should also look for ways to improve the shielding. Look for openings that can be covered up and for places where walls and ceilings can be thickened to cut down on gamma penetration.

In the example shown in Figure 4-3, the radiation safety could be improved with a little effort. Earth could be piled up around the outside where the basement wall rises above ground level. All but two or three basement windows could be sealed with boards or with cardboard and plastic and then covered with earth. The remaining windows may be needed for ventilation and should be baffled rather than sealed. A way to construct a baffle over a basement window to reduce gamma penetration and prevent fallout from entering is shown in Figure 4-4.

About 40-50 man-hours of labor would be needed for the improvements in the radiation safety of this shelter. Shovels, picks, and some carpenter’s tools (hammers and saws) and supplies (nails, lumber, plywood, plastic sheeting and gloves) would be needed People who are not accustomed to manual labor should wear gloves from the start when picking or shoveling earth. Blisters are painful and can develop into serious infections, especially if antibiotics aren’t available.

These efforts could improve the FPFs of this shelter by factors of four to 10. If the FPF of the safest location were about 25 before these improvements, the FPF could be 100 to 250 afterwards. If the fallout is heavy, this improvement could mean the difference between life and death for the occupants.

4. **Openings and Ventilation -** Are there openings to be baffled or covered to reduce the amount of radiation coming through them? Will these changes allow enough air to flow through to keep people from getting too hot when they are crowded?

Both the Shelter Manager and the RM will be involved with the problem of providing enough ventilation while maintaining the best radiation safety, as mentioned in paragraph 4-2b.

In the basement shelter of Erskine Hall (sketched in Figure 4-3), all the windows except two or three should be sealed and covered with earth, as discussed in paragraph 4-2b. Two or three windows should be left uncovered to provide ventilation. These uncovered windows should be located on the side where fallout is least likely to pile up. If the wind usually blows from the Northwest, these uncovered windows should be located on the South or East side. In Figure 4-3, if the top of the figure is North, the uncovered windows should be the two windows near the corner in Room F. If the local wind is blowing from the Northwest when fallout is coming down, there may be less radiation buildup at the open windows on the Southeast side.

These two uncovered windows should have a baffle or wall built around them with earth piled up on the outside (as shown in Figure 4-4), to reduce the gamma radiation which shines directly into the shelter from fallout on the ground. If the bottom of the window is at ground level, the inside of the baffle should be dug down several inches below the level of the window to provide a trap for fallout particles. If plastic or plywood sheeting is not available, a trough or a pipe from the inside of the enclosed trap to the outside ground level at a lower point is needed to provide drainage.

5. **Materials for Shielding -** Are materials and tools handy which could be used for putting up improvised shielding after fallout arrives?

You may have improved the radiation safety of the shelter to the best of your judgment and capability, as discussed in paragraph 4-2b. But after fallout arrives, you may find with the use of your survey meter that gamma radiation is shining through at some unexpected location. You should know where and what materials are available to stack up against or cover a wall, doorway, window, or portion of a ceiling to reduce the gamma penetration. Such materials as books, bricks, earth, or wood may be used. Other materials and their shielding effectiveness are listed in Table 1-2. If some of these materials are located outside the shelter, set up (or ask the Shelter Manager to set up) a work crew to move as much of it inside as possible before fallout arrives.

6. **Entranceway Problems -** Is there going to be a problem if a lot of people enter the shelter while fallout is coming down?

One problem that could develop is that the shelter entrance could be blocked by people who have stopped just inside the entrance. They may have stopped to brush off fallout particles or if the shelter is a large building, they may not know where to go.

If there is a possibility of problems at the entrances, one or two people should be selected to be receptionists at each entrance. The receptionists should see that people brush off fallout and shake outer garments if they come to the shelter after fallout begins to come down. Decontamination of people caught in fallout is described in paragraph 4-4a. The receptionists should also show people where to put outer garments from which fallout particles can’t be shaken easily, show them where to go in the shelter, sweep or vacuum fallout particles whenever they accumulate, and throw the swept-up particles outside.

The receptionists will need to wear dosimeters and must know how to read them. They should leave the entrance area and go back to the safest part of the shelter as soon as their dosimeters read some pre-selected limit, such as 10 R. They may leave sooner if no one has arrived after fallout begins to come down.

The receptionists should set up places to store umbrellas, coats, and other outer garments if there are no convenient places to put these articles near the entrances. They should also have brooms and dustpans available.

It may be helpful to tape up sheets of paper near the entrances, which show the way to the safest places in the shelter. If there are no receptionists at the entrances, tape up a sheet of paper near the entrances with information on how to decontaminate oneself.

7. **Restroom and Water Locations -** Are trips for water or to restrooms going to increase radiation exposure?

The RM, (Radiological Monitor) should note where drinking fountains, water outlets, and restrooms are located throughout the shelter. After fallout has arrived, he or she should check the radiation levels at these locations. Some of them may have to be blocked off until the radiation decays to a safer level.

In nearly all public fallout shelters, there will be plenty of water for drinking, cooking, and flushing toilets as long as there are no nuclear detonations close enough to break water lines, damage storage tanks, or cause an electric power failur4e. If a distant nuclear explosion knocks out the electric power, there will still be water in the pipes and tanks, which will flow by gravity. Water should be used as needed for drinking and sparingly for other purposes throughout the emergency.

In a nuclear war there is a possibility that the water supply might fail, so water should be stored in the shelter before fallout arrives. If the shelter runs out of water in a heavy fallout area, the RM may be faced with some difficult decisions and unpleasant situations. About a two weeks supply of water should be stored in areas where heavy fallout is expected. About two weeks after fallout has arrived, the radiation intensity even in the worst places will decay to levels where people can make emergency trips without the risk of radiation sickness or death. In areas where heavy fallout is exp3cted and in the case of hot, crowded conditions in the fallout shelters, a minimum of about seven gallons of water should be stored per person, just for drinking.

8.**Dosimeter Locations -** Where could dosimeters be mounted or hung? Are needed materials available for mounting or hanging them?

In some shelters where the FPF is high and about the same everywhere, as in deep underground shelters, caves, and mines, only a few dosimeters need to be mounted or hung where people will be located, to get an idea of what total exposures they are getting, if any. Tape, thumbtacks, nails, and string can be used to mount dosimeters.

In shelters where the FPF may change as you move from one location to another, you will need to issue one or two dosimeters to each shelter Unit Leader. The Unit Leader will then be responsible for estimating radiation exposure readings for the members of his or her unit. At certain times of the day or night, the Unit Leader may want to mount or hang one dosimeter in the vicinity of his or her unit and will then need materials for mounting or hanging it.

9. **Instrument Storage -** Where can instruments, instrument supplies, flashlights and batteries be stored securely?

A central and secure location should be found for storing these items. In the shelter sketched in Figure 4-3, the closet under the stairs in Room G can be used. If you can’t lock the door when you must leave, find someone to watch over the supplies. Don’t let children play with the radiological instruments.

10. **Light Sources -** Are there enough candles, lanterns, flashlights and other light sources to provide light so you can move around and read the instruments if the power goes out?

As mentioned before, electricity may fail in many locations due to a wide-scale nuclear attack. Most of the shelters with the highest FPFs will also have the least daylight reaching them. If the power goes out, these shelters may be pitch black. Some light must be provided so people won’t get hurt when they try to move around. You will need a light of some kind to read the radiological instruments. You should have your own flashlight or lantern so you can move around freely and read your instruments whenever necessary.

11.**Writing Supplies -** Are writing supplies available, including pens or pencils and printed forms or paper, for keeping records of radiation exposure?

The radiation exposure of each shelter occupant should be recorded every day and for any special trip that increases the person’s exposure. A sample radiation exposure record is shown in Figure 4-1, and at the back of this handbook. If enough printed forms for this record are not available, ordinary notebook paper or stationery may be used. If no paper is on hand in the shelter and none is obtainable before fallout arrives, the records may be written on the walls or on whatever materials and surfaces are available.

Remember, the main purpose of the record is to help people limit their radiation exposure and prevent radiation sickness. If people don't know what they've been exposed to, they won't know whether they are going to get radiation sickness if they make a trip out of the shelter. Each person needs to know their own exposure so he or she can decide whether a trip outside can be safely made.

It will be useful to have a lot of paper to write and draw on in the shelter, not only for radiation records but for shelter sketches, messages, and bulletins. You will need a notebook, which we will call the RM Log, to keep a record of events. In this log you should enter such information as the time and date and a brief description whenever explosions are heard or detected, when fallout arrives, when the peak radiation exposure rates are measured, when and where special measurements are made, and when there is trouble with instruments.

c. **Getting and Checking the Instruments -** Each County may have a slightly different procedure for getting radiological instruments to the shelters, if they are not there already. In some counties the instruments may be delivered, but in most counties the RM will be expected to pick up the instruments for the shelter. If you are selected to be a 'RM' after you arrive at the shelter, you may have to find out where the instruments are, and you may have to make a special trip to get them. Instructions on how to use the instruments may be given at the place where they are issued. If the RM has not used the instruments recently and no instructions are given, the RM should read Chapters 2 and 3 of this handbook before trying to operate them.

If available, there should be at least one dosimeter for each shelter unit (paragraph 4-2a, "Organization of Shelter Population") and one dosimeter each for the Shelter Manager and the RM. It would be desirable to have one survey meter for approximately every 200 occupants in a shelter and as many dosimeter chargers as there are survey meters. You should get one extra D-cell battery for each survey meter and each charger. If extra batteries are not supplied with the instruments and if there is time, go to a store and buy them.

An operational check on the instruments should be made as soon as they are received, preferably at the place they are issued. Instructions for operational checks are given in Chapter 3 of this handbook.

When you have the instruments at the shelter, go through another operational check. Zero the dosimeters, if they haven't been zeroed already (paragraph 3-4b, "Charging or Zeroing the Dosimeter"). If there is time, start a leak check on all dosimeters (paragraph 3-4c, "Checking Dosimeters for Leaks").

Let the Shelter Manager know that you have the instruments and their condition.

Keep the instruments in a secure place until they are put to use. If you can't lock them up, find someone reliable to watch over them.

d. **Informing the People in the Shelter about Radiation Exposure -** Many people have a great fear of "invisible death" from nuclear radiation. There will be much anxiety among people in a shelter when it is known that they are getting radiation from fallout. Even if people are frightened, it is better not to hold back information. The policy of "what they don't know won't hurt them" has never worked with the American public.

When the presence of fallout radiation first causes the needle to move up on the survey meter, the people in the shelter should be informed. If there are several people watching the survey meter, the news of fallout radiation will travel very quickly through the shelter.

In order to let people know the radiation levels, select at least one place in each small or medium-sized room where people are sheltered (more places in large rooms) to mount a sheet of paper on which the survey-meter readings taken near the paper will be written periodically. A sample sheet is shown in Figure 4-5. This sheet and the measurements will be discussed again in paragraphs 4-4f and 4-5a.

If there is time before fallout arrives, each shelter Unit Leader should be shown how to read a dosimeter. Each Unit Leader should be encouraged to read the first chapter of this handbook, if they haven’t read it already. If there is only one copy, the fastest readers should be the first ones given the handbook to read.

4-3. **Watching for Fallout to Arrive -** People may find that a nuclear attack is about to happen or is on its way by announcements on the radio or television by sirens or other warning devices, or by word of mouth. When a nuclear weapon explodes anywhere within several hundred miles, there will be many signs to indicate it. By that time, people should be on the way to, or already at their shelter. No one should be outside or very far from a shelter when fallout begins to come down.

A nuclear explosion several hundred miles away can cause an electromagnetic pulse (EMP) which may burn out the transmitting capability of some radio and television stations and knock out some telephone circuits. The EMP may also affect power lines, causing momentary blackout or flickering of lights. It may cause a lot of static similar to lightning static in AM radios, and may burn out FM radios or televisions with large antennas. Nuclear explosions near power lines or power stations may cause widespread power blackouts. Nuclear explosions produce a brilliant flash and glow in the sky, which may be seen 50-100 miles away in the daytime if the weather is clear, and much farther at night. STARING AT THE FLASH MAY CAUSE EYE DAMAGE EVEN IF THE BURST IS FAR AWAY. A shaking of the ground as in a mild earthquake may follow within a few minutes, depending on the distance from the burst.

The following procedure applies to shelters that are located at least 25 miles away from a likely target for a nuclear weapon. After nuclear explosions have taken place with noticeable effects in or near the shelter, or when notified by the EOC, the RM (for whom the following is written) should take the survey meter outside or by an outside window (on the windward side, if possible) and watch for the arrival of fallout. If the FPF of the shelter is high and the fallout is light in the area, the survey meter may not show that fallout has arrived if the meter is kept at the safest place in the shelter. It is necessary to know when fallout has arrived, even if it is light, so that exposure control measures can be started.

If you, the RM, must go outside, keep fallout particles from getting in your clothes and on your skin and hair. Carry an umbrella and wear a hot and an outer garment if available. You should enclose your survey meter in a clear plastic bag, if available, to keep it from getting contaminated. Carry a dosimeter in a breast pocket or on a chain or string around your neck. Take along a transistor radio or a two-way radio, if available, to keep informed of the situation around you. If it is nighttime, take a flashlight along even though the power may be on and th3 area may be brightly illuminated at the time you start your watch. If fallout is expected to arrive within the hour, zero your survey meter and leave it on with the range-selector switch turned to ‘X0.1’ If fallout is not expected to arrive for an hour or more, leave the survey meter turned off to save the batteries. You may want to turn it on every 10 or 15 minutes just to check the situation.

SURVEY-METER READINGS

LOCATION: 1. CENTER, NORTH WALL, ROOM G, ERSKINE HALL

Date	Time	Reading (R/hr)	Comments	Date	Time	Reading (R/hr)	Comments
5 JULY	1020	0.10	FIRST FALLOUT READING	5 JULY	1630	2.75	
"	1030	0.18		"	1645	3.0	CLIMBING AGAIN
"	1045	0.50			1700	3.5	
"	1100	0.87			1715	4.0	
"	1115	1.2			1730	4.5	
"	1130	1.55			1745	5.0	
"	1145	1.95			1800	5.5	
"	1200	2.3			1815	5.75	
"	1215	2.75			1830	6.0	
"	1230	3.0			1845	6.0	
"	1245	3.25			1900	6.2	
"	1300	3.25	LEVELING OFF		1915	6.2	LEVELING OFF
"	1315	3.25			1930	6.2	
"	1330	3.25			1945	6.0	FALLING AGAIN
"	1345	3.25			2000	6.0	
"	1400	3.25			2015	5.75	
"	1415	3.25			2030	5.75	
"	1430	3.25			2045	5.5	
"	1445	3.15	FALLING		2100	5.5	
"	1500	3.10	EXPLOSION HEARD				
"	1515	3.05					
"	1530	3.0					
"	1545	2.95					
"	1600	2.9					
"	1615	2.85					

Figure 4-5. Sample survey-meter readings at location 1 in make-believe Erskine Hall.

If fallout arrives from a ground explosion 25-75 miles upwind, depending upon the yield of the weapon, you will probably notice its arrival by the sound of gritty particles striking the window or surfaces around you. You may hear these gritty particles striking for many seconds before the needle on your survey meter begins to climb. When the needle reaches 0.1 R/hr, note the time; enter the shelter; decontaminate yourself (paragraph 4.4a) if you have been outside; record the reading, time, and date in your RM Log; and tell the Shelter Manager and occupants that fallout has arrived. If fallout arrival is to be reported to your EOC, it should be done in accordance with your local plan.

Some people may be working outside the shelter to improve its radiation safety, or they may be carrying shielding materials into the shelter up to the last minute before fallout arrives. They may become aware of the arrival of fallout by noticing gritty particles striking their skin, by hearing them strike nearby surfaces, or by seeing the buildup of particles on surfaces. These people should then go inside the shelter and brush the fallout particles off their clothes and bodies. If they do not notice the arrival of fallout, you, the RM, should tell them that the arrival of fallout has been detected by the survey meter.

If fallout comes to the shelter from many large ground bursts 100 miles or more upwind, the fallout may not arrive for many hours. The fallout may be hazardous even though it arrives as late as 24 hours after the explosions. You may decide not to set up your own watch for fallout for that length of time if your shelter has good two-way communication with the local EOC. If the people in your shelter feel they can rely on the local EOC, they may decide to depend on the announcements from the EOC to let you know how fast fallout is coming to your shelter. These announcements should come at least every half-hour or hour from the EOC, depending on the situation. When it appears that fallout might arrive at your shelter in two or three hours, take the survey meter to a window or outside and begin to watch for fallout.

The people in the shelter may want to have their own lookout for fallout, even though the EOC may seem to be reliable. If you expect the fallout to take a long time to arrive, arrange for people to take turns or shifts in watching for its arrival.

When fallout arrives from distant explosions, you may not notice it as much as you would notice the fallout from closer explosions. The particles may be so small that you may not feel them as they land on your skin. The climbing of the needle on the survey meter may be the only indication that fallout from distant explosions has arrived.

The fallout is carried most of the way to its destination by winds at high altitudes. On some days the wind at high altitudes may be blowing in a different direction from the wind on the ground. Under these conditions, you might think fallout from a particular nuclear explosion will not come your way because the wind where you are is not coming from the direction of the explosion. In this situation, the fallout might arrive at your shelter contrary to your expectations. The direction that the particles are blown by the surface winds may make it seem that they are coming from the wrong direction. Unless you have positive information on the direction the fallout is being carried, do not make any assumptions about where it will come down.

4-4 **While Fallout is Coming Down**

a. **Decontamination of People Caught in Fallout -** Fallout arriving within a few hours after a nuclear explosion is highly radioactive. If it collects on the skin in large enough quantities it can cause beta burns (see paragraph 1-8b, "Symptoms of Radiation Injury").

People who are caught outside in fallout should brush fallout particles off themselves and shake out their outer garments as soon as they get inside the shelter. Some people may be carrying umbrellas and wearing raincoats to keep the fallout particles off their skin and hair. If people have not taken such precautions, they should try to get the fallout particles off their skin and out of their hair and clothing as much as possible before going further into the shelter, but they should not block the entrance so others can't get in. It is more important that people get into the shelter than it is to get every speck of fallout off every person before they go further into the shelter. Fallout particles that are carried into the shelter can be swept up and thrown outside.

If there is a possibility of blockage at the entrances because of a lot of people coming to the shelter after fallout arrives, one or two receptionists should be assigned to each entrance to supervise the decontamination. Each receptionist should wear a dosimeter. Arrangements should be made for them to be replaced so they can leave the entrance area as soon as their dosimeters show that they have been exposed to some pre-selected limit, such as 10 R, or radiation. If only one or two people come every few minutes to the shelter, the receptionists should go back to the safer parts of the shelter. Instructions for decontamination and directions to the safest shelter locations should be printed on sheets of paper and taped or tacked up in places where incoming people can easily see them.

Most fallout particles will be like grains of fine, dark sand and can be easily brushed off from dry surfaces. The particles can be removed from tightly woven fabrics and rainwear by lightly shaking them.

Loosely-woven outer garments such as knitted sweaters, shawls, and scarves may hold fallout particles even after a hard shaking. These garments should be stored in a special place set aside for them until they can be washed. After they are washed, they will be suitable for normal use. The fallout particles will come out in the wash, and the fallout particles or the radiation will not damage the fabric or make it radioactive.

Fallout particles may stick to moist or oily surfaces, including sweaty or oily skin or hair. These surfaces should be carefully wiped or washed off. If contaminated hair cannot be washed, it should be thoroughly brushed or combed, with frequent shaking and wiping of the hair or also of the brush or comb.

It is not necessary to get the last speck of fallout out of the clothing or hair or off the skin. A few grains of fallout carried by each person into the safest parts of the shelter will produce no noticeable increase in the radiation hazard and will not be detectable by the radiological instruments. Daily sweeping of the shelter for hygienic reasons will eliminate most fallout particles that may be carried into the shelter even after decontamination procedures.

The reception area should be organized so people can shake out their outer garments without getting the particles on people around them. After they have shaken out their clothing and wiped off their exposed skin, they should move further into the shelter and sweep the dust off their shoes with a brush or broom. If the shoes are caked with mud or dust, they should be left in the reception area.

Because the fallout particles will fall down to the floor, decontamination of a person should begin with the head and end with the feet. Brushing off or removing the shoes will be the last step of decontamination before a person enters the safer parts of a shelter.

b. **Finding the places with the lowest radiation levels in the shelter -** After the announcement is made to the people in the shelter that fallout has begun to dome down outside, you (the RM) should use the survey meter to find the places that have the lowest radiation levels. The people in the shelter should be gathered at the locations that are estimated to have the lowest radiation levels. It should be explained to the people, or at least to the shelter Unit Leaders, that these locations were chosen on the basis of estimates and that places with lower radiation levels might be found by taking readings with the survey meter.

Mark the sketch of the shelter to show the locations where you plan to take readings of the radiation levels. Some of these readings should be taken near walls, posts, or columns upon which you can tape a form showing your readings. An example is shown in Figure 4-5. A general survey of radiation levels with the survey meter should be made as soon as possible after the gamma radiation reaches levels that can be detected inside the shelter. Write down the readings, the times the readings were made, and the exact location for each reading so you can find the same spot when you check later. You may wish to mark the floor where you make your measurements and assign a number to each location.

At this time, when you are trying to find the safest places in the shelter as quickly as possible, you should take readings only in those locations where you estimate the lowest radiation levels will be. For example, if you are in a basement shelter you should not take readings on the first floor at this time. If you are in a skyscraper shelter, there is no need to take readings near an outside wall at this time. The first survey should be spread out to get a general picture of the best shelter areas. Follow-up surveys should then be made to get a detailed picture of radiation levels in the areas where people are finally sheltered.

While fallout is coming down, the radiation levels may be climbing fast. Inside the shelter at the location that you have estimated to be the safest, your survey meter needle may be climbing as fast as one to five smallest divisions on the ‘X0.1’ SCALE EACH MINUTE. If you plan to make a detailed comparison between the readings at several locations, the reading at the final location may be quite a lot higher by the time you get to it than it was when you began to take readings. You will not be able to tell whether the higher reading results from a lower FPF or from an increase in radiation levels at all locations of the shelter. The readings would have to be taken in both places at the same time to show which location had the lowest radiation level. You can only be at one place at one time!* You should not wait until the radiation levels stop climbing to make your detailed follow-up measurements, because it might be several hours before the fallout stops coming down. To get a proper comparison of the radiation safety between different locations while the radiation levels are climbing rapidly (due to the buildup of fallout), you will need to use a special method for taking measurements. One of the simplest methods for taking such measurements is the TIME-AVERAGING method described in paragraph 4-4c.

*If your shelter has two or more survey meters (most will not) and two or more RMs, you may work out a simpler method by making readings synchronized by timepieces showing seconds or by the use of two-way radio communication between the RMS. The meters should be compared at one location (identical radiation levels) before AND AFTER the measurement (the instruments may drift) to make sure they read the same or to compensate for different readings.

Another method, to be used if no survey meter is available, is to place a dosimeter at each location to be checked. All the dosimeters to be used should be carefully zeroed at approximately the same time before positioning them. You may have to wait several hours before significant differences in the readings are observed, because the smallest division on the dosimeter is 10 R. With a survey meter, you will be able to compare the radiation levels at several locations within just a few minutes by using the time-averaging method.

c. **The Time-Averaging Method -** The time-averaging method is used to compare the radiation levels between two or more locations in a shelter when the radiation levels are climbing rapidly and when you have only one survey meter. If only two locations are to be compared and only a few seconds are needed to get from one location to another, the time-averaging method need not be used. The readings obtained at the two locations may be compared directly in that case.

The time-averaging method is a way to estimate what the approximate radiation levels WERE ast several locations at ONE particular time. It consists of taking readings at different locations BEFORE AND AFTER one particular time, then averaging those readings to get the reading at that particular time.

If only two locations are to be compared (locations 1 and 2), a reading is first taken at location 1. A short time later, a reading is taken at location 2. After another short period of time OF EQUAL DURATION, whether 30 seconds or one or two minutes, a reading is taken at 1 again. The two readings taken at 1 are then averaged (add them and divide by two) and compared with the reading at 2.

If three locations are to be compared (locations 1, 2 and 3) with equal time intervals of say, one minute between readings, the readings are taken at locations 1, 2 and 3 and then at locations 2 and 1 again, IN THAT ORDER. The order of measurements, 1-2-3-2-1, must not be changed. The two measurements at 2 are taken ONE MINUTE BEFORE and ONE MINUTE AFTER the measurement at 3, the middle or CENTRAL measurement. The two measurements at 1 are taken TWO MINUTES BEFORE and TWO MINUTES AFTER the central measurement. The two readings at 1 are averaged, and the two readings at 2 are averaged to give approximations of what the readings would have been at those locations at the same time that the reading at location 3 was taken.

To use the time-averaging method, you will need a wristwatch or clock that shows seconds as well as minutes. You should have an assistant to help you move quickly through crowds of people, watch the time, and help keep track of the measurements.

Remember that the survey meter does not respond instantly to the radiation it is measuring when the range-selector switch is turned to ‘X0.1’. You will need to allow a few seconds at each location for the needle on the meter to reach its final reading. Do not move, jiggle, or rotate the survey meter while the needle is settling down.

The survey meter should be held about three feet above the floor or at about waist level and about two feet away from the body when taking measurements. If you are taking measurements in a ground level or below-ground shelter full of people, it is important that all the people sit or lie on the floor while you take the measurement. If people are standing, they will shield some of the gamma radiation from your instrument, and your survey meter will then show a lower reading than it would if people were sitting or lying down or if the room were empty. If you used this reading to compare with readings in other locations that are empty, you might conclude that the room with the people in it is safer, although it may actually be more hazardous.

If you plan to compare the readings at several locations, start the first reading where you think the reading should be the lowest, which should be where the people are located. Begin the readings 20-30 minutes after the needle reads about 0.1 R/hr in the safest location, after you have made your first rapid, spread-out survey. If you start in another location, you may find that when you get to the estimated safest location, the radiation level may still not be high enough to read on the meter. You will then have to repeat the measurements later.

The 20 to 30-minute waiting period will allow time for enough fallout to settle on the ground so the readings will not be influenced much by radiation from fallout particles still in the air. You may wish to use this period to choose the exact locations where you will take measurements, mark these locations on your sketch and at the actual spot, and prepare a sheet of paper or a page in the RM log so your measurements can be written in the correct place when you take them. You should have an assistant with you while you make these preparations so he or she will know what to do when you are taking the measurements. An example of the time-averaging method for comparing seven locations is shown in Table 4-2.

The RM for the shelter in make-believe Erskine Hall, introduced in the discussion in paragraph 4-2b(1), used the time-averaging method to compare the radiation safety of the seven rooms in the basement. The locations where the RM made the measurements are shown in Figure 4-6.

People were packed together in Room G, where the RM made the first and last readings. The choice of locations where readings were taken and the order in which they were taken was made before fallout arrived.

Note: Twenty-four hour time is used to prevent confusion between AM and PM. This way of telling time is used by airlines and the military. The first two digits indicate the hour of the day, starting with zero at midnight, and the second two digits indicate the minutes after the hour. The 24-hr. time in the afternoon is obtained by adding 12 to the 12-hr time in the afternoon (hours past noon). Thus, 1:10 PM (ten minutes past one) becomes 1310 hrs, 2:20 PM becomes 1420 hrs, etc. See Appendix B for a table to convert standard time to 24-hr time.

Fallout arrived at Erskine Hall at 1009 hrs.,* and the first radiation reading inside the shelter was made at location 1 at 1020 hrs, as shown in Figure 4-5. A rapid survey throughout the basement roughly confirmed that Room G provided the best radiation protection. It was decided the first series of detailed measurements for time-averaging would begin at 1040 hrs. The survey meter was brought to each designated location with enough time allowed to hold the meter in position for 10-15 seconds before the reading was taken. The first reading was taken at 1040 hrs and the last at 1054 hrs. Readings at location 1 were made seven minutes before and seven minutes after the central reading was taken at 1047 hrs at location 7. Readings at location 2 were made six minutes before and six minutes after the central reading at location 7, and so on. While moving from location 2 to location 3, the RM was delayed by a disturbance between some occupants of the shelter, so the reading at location 8 was taken at 1043 hrs instead of 1042 hrs as initially planned. In order to maintain the same time interval between the ‘before’ and ‘after’ readings at locations 1 and 2, the ‘after’ readings at those locations were delayed a minute to 1054 hrs and 1053 hrs, respectively, instead of 1053 hrs and 1052 hrs as initially planned. The two readings made at each location (except where the central reading was made) were added and divided by two to give an estimate of what the readings would have been at those locations at the same time the central reading was taken (1047 hrs.) at location 7. These time averages are listed at the bottom of Table 4-2. From these readings, it was confirmed that Room G (location 1) provided the best radiation protection in the basement of Erskine Hall. Note that the readings at locations 1 and 2 almost doubled between the ‘before’ and ‘after’ readings.

Table 4-2. An example of the use of the time-averaging method.

Location[a]		Measurements					Time-Average Radiation Rate (R/hr) (total divided by 2)	Comments
		Time		Survey Meter Reading (R/hr)				
Room Name	Location Number	Before	After	Before	After	Total		
G	1	1040	1054	0.41	0.74	(1.15)	0.575	Lowest rate
A	2	1041	1053	0.73	1.19	(1.92)	0.96	One-minute delay
B	3	1043	1051	0.69	0.95	(1.64)	0.82	
C	4	1044	1050	1.01	1.29	(2.30)	1.15	
F	5	1045	1049	1.32	1.55	(2.87)	1.435	
E	6	1046	1048	0.79	0.86	(1.65)	0.825	
D	7	1047		0.96			0.96	Central measurement

[a]Figure 4-6 shows where these locations are in the basement of Erskine Hall.

Note: This example results from an imaginary situation at Erskine Hall in which the time-averaging method is used to compare the radiation safety of various rooms when radiation levels are rising rapidly. The numbers are presented here as they might be entered by the RM in the RM log. The location numbers are entered on the sheet before starting. The columns marked 'Before' under both the 'Time' and the 'Survey Meter Readings' are filled in from top to bottom as the measurements are made, and then the columns marked 'After' are filled in from bottom to top. The numbers in parentheses in the column marked 'Total' are obtained by adding the 'before' and 'after' survey-meter readings at a location. The time-average radiation rate at a location, except for the central measurement, is obtained by dividing the total by two.

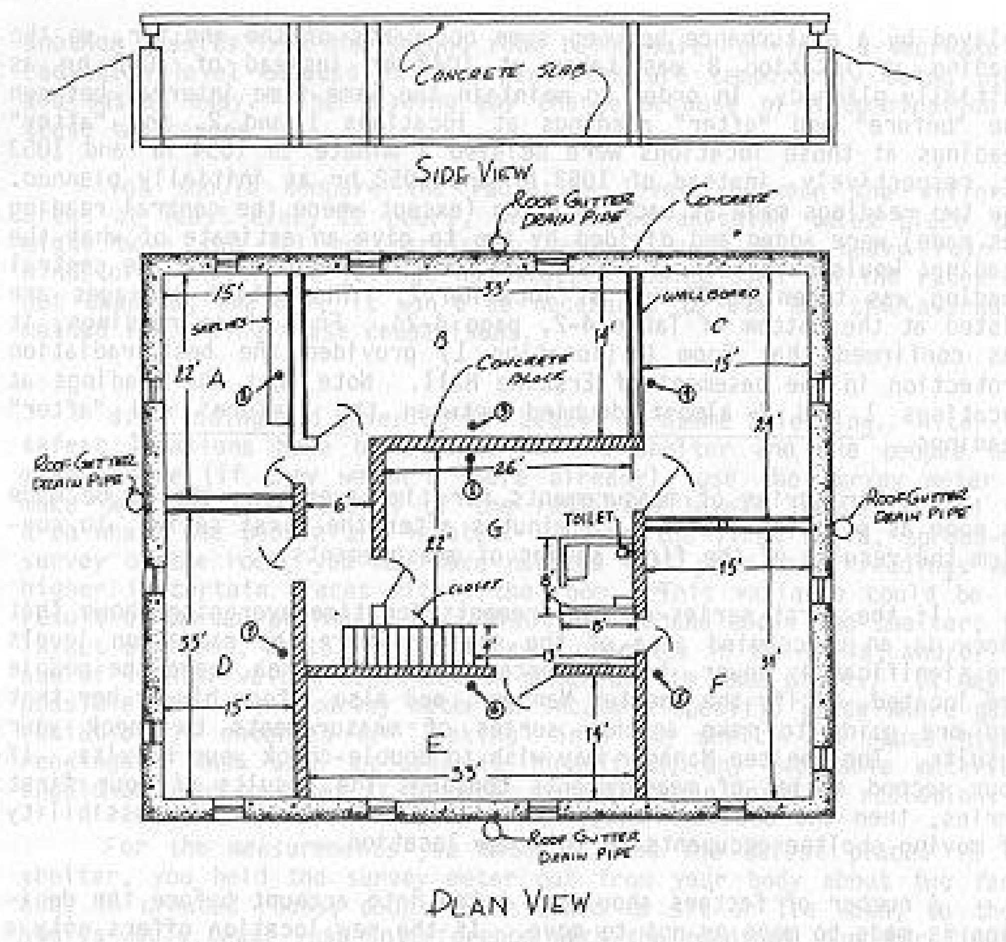


Figure 4-6. Locations of survey-meter readings for time-averaging in the basement of Erskine Hall are shown by dots and are identified by numbers in circles.

Another series of measurements for time-averaging should be made as soon as practical, within 20 minutes after the first series, to confirm the results of the first series of measurements.

If the first series of measurements for time-averaging shows that there is an unoccupied area of the shelter where the radiation levels are significantly lower, say 20 percent, than the area where the people are located, notify the Shelter Manager, and also inform him or her that you are going to make another series of measurements to check your results. The Shelter Manager may wish to double-check your results. If your second series of measurements confirms the results of your first series, then the Shelter Manager will need to consider the possibility of moving shelter occupants to this new location.

A number of factors should be taken into account before the decision is made to move or not to move. If the new location offers only a slight reduction (less than 20 percent) in radiation levels, a decision not to move may be made for several reasons, such as: (1) there may be less space, less desirable space, and/or not enough ventilation in the new location; 2) the location of the new space may result in higher radiation exposures to occupants while they walk to restrooms or to eating facilities; and 3) fire escape routes may not be as good. If the new location offers substantially lower radiation levels, a decision to move may be made in spite of such shortcomings, especially if it appears that the radiation intensity may climb to such high levels that the accumulated exposure may result in radiation sickness. Even if the current fallout is so light that radiation sickness is not likely, the Shelter Manager may decide that the occupants should move in order to be better prepared for the possibility of additional fallout from future attacks.

If a sudden squall or weather front with high winds and heavy rain strikes the shelter while you are in the process of taking readings for time-averaging, you may need to disregard your measurements and wait until the weather settles down before you try the readings again. You may not be able to tell whether a decrease in reading from one room to another results from the second room being safer or from a decrease in radiation level because fallout particles are temporarily being blown and washed away. The reading may change because of a combination of these two causes.

You should compare the radiation levels between the different areas at least every 12 hours, or whenever anything takes place that might move the fallout particles around, such as a heavy rain or windstorm. After the fallout has stopped coming down and the rates are not changing rapidly, it won't be necessary to use the time-averaging method for making these comparisons.

d. **Finding and covering up 'Leaks' in Gamma Shielding -** After the safest locations have been found in the shelter and the people have moved there (if they weren't there already), use the survey meter to make detailed measurements of the radiation levels in and around the area where the people are located. During the first rapid, spread-out survey of the room, you may have noticed that your meter readings were higher in certain places within the room. This variance could be the result of uneven piling-up of fallout around and above the shelter; the layout of rooms, walls, and stairways; openings in the walls; and/or the use of lighter-weight construction materials in some places. It may be possible to use the survey meter to locate a specific place where gamma radiation is entering or 'leaking' into the shelter to cause higher readings. When such an area is identified, any available materials should be used to cover it in order to reduce the level of radiation.

For the measurements you made to find the safest places in the shelter, you held the survey meter out from your body about two feet, and in crowded rooms, people were asked to sit or lie down, so their bodies would cause less interference with the reading. But for finding gamma leaks, yu can make use of that interference.

The survey meter responds to gamma rays almost equally as well from all directions. If gamma rays come in greater intensity from one particular direction, you can't detect the direction just by pointing the instrument toward it. But you may be able to use the shielding provided by your body and others to reduce the radiation coming from the direction where you and others are grouped together; the survey meter will then respond more to radiation coming from OTHER directions than from where you are standing. For example, if a group of people crowd around a survey meter and leave an opening in only one direction, the reading on the instrument will be caused mostly by radiation coming through the opening, providing there isn't a lot of radiation coming down through the ceiling or up from the floor. This method has not been tested in practice, and you may be able to improve it as you try it. Also, you may find that it does not work in your particular circumstances.

The measurements are made as follows: Select a starting place somewhere along a wall, at a corner, at a door or window in the shelter room. Mark that location on the floor or on the wall with a piece of tape or by writing directly on the surface. Use a letter to designate the room and a number to designate the place where the measurement is taken in the room. For example, the first measurement in Erskine Hall would be taken at a spot marked 'G-1', because the room marked 'G' on the shelter sketch is the room where the people are sheltered. Hold the survey meter against your waist and face the wall with the survey meter against the wall or a few inches from it. Have an assistant write down the location designation, the time, and the survey-meter reading in the RM log or on a sheet of paper.

Move three or four feet to your right or left (it doesn't matter which direction you go as long as you keep going in the same direction) along the wall and mark the location with the same letter as before, but with the number '2' ('G-2' in Erskine Hall, for example). Hold the survey meter as before, read the dial, and again record the location, time, and reading. Continue the measurements until you have gone completely around the room and have reached your starting point.

It is important that you take readings in the middle of doorways, windows, other openings or irregularities in construction. You may have to break your pattern of equal spacing between measuring locations in order to obtain these special measurements.

You will very likely be taking these measurements while fallout is still coming down. As you go around the room, the readings will become higher and higher in a fairly regular pattern unless you find a place that appears to be a 'leaky' area. As you approach such a place, the readings will increase more between readings than before, and as you go beyond the area, there will not be as much of an increase in the reading; in fact, there may be a decrease in the reading. Because the radiation levels will be increasing at a fairly regular rate under most conditions, you should try to MAINTAIN AN EQUAL TIME INTERVAL BETWEEN MEASUREMENTS as you go around the room. A time interval of 20 or 30 seconds may be about right. Don't try to go too fast or you might not be able to keep up with the schedule. If you notice an area that appears to be 'leaky', don't slow down. Continue with your measurement schedule around the room. You may need to ask the Shelter Manager to give you some assistance to make sure that nothing will interfere with your schedule of measurements.

After you have completed your measurements around the room, examine the numbers your assistant wrote down for indications of 'leaky' areas. If you find any indication of such areas, tell the Shelter Manager. You should also tell him or her that you will need the assistance of several people to help you decide whether there is an actual leak of gamma radiation at the locations or whether the readings are a result of the way the scattered gamma radiation happens to be focusing at that location.

You will need to repeat your measurements in the vicinity of the suspected area, starting at the location just before the increased numbers were recorded, and make measurements, again AT REGULAR TIME INTERVALS, until you have passed the suspected area; but this time the people in the vicinity of the area should be asked (possibly by the Shelter Manager, depending on the situation) to stand and press fairly close to you while you make each measurement. The shielding that is provided by their bodies will block out scattered gamma radiation that comes from different directions inside the room. If the readings still show an increase as you approach the area and a decrease as you go past it, there is a 'leak' of gamma radiation in the area you are surveying. This leak could come from the area in front of you, or it could come from above (or below, if you are in an above ground shelter). If the readings no longer show an increase as you approach the area and a decrease as you go past it, the previous reading (without the people standing closely behind you) was caused by the pattern of scattered gamma radiation in the room, not by a gamma leak.

If you are trying to find gamma leaks in an empty room, you may use the ‘front-to-back’ method. In this method, your own body is used as a shield to try to find from what direction the gamma radiation is coming. Again, this method has not been tested in practice, and you may be able to improve it as you try it, or you may find that it won’t work in your particular circumstances.

To try to find a gamma leak, hold the survey meter tightly against your stomach and face the area where you expect extra gamma radiation to be coming from. If you are working with the range-selector switch turned to ‘X0.1’, wait a few seconds before taking a reading. This reading will be called a ‘front’ reading. Turn around so your back faces the suspected leak, and with the survey meter still held tightly against your stomach, take another reading. This reading will be called a ‘back’ reading. If there is more radiation coming from the direction you faced for the first reading than from the opposite direction, the front reading will be higher than the back reading. As you slowly turn around, you may notice that the meter needle goes through the lowest reading when you are facing a particular direction. The radiation leak is then at your back. Repeat these ‘front-to-back’ readings at different places and directions until you have a fairly good idea of where the extra radiation is coming from. The difference between the front and back readings may be made greater, if the radiation is actually coming from one direction more than another, by having several others stand alongside and behind you when you make the measurements. The extra shielding provided by their bodies will take out more of the radiation from the rearward direction, which is what you want to do while making this type of measurement.

When you are fairly certain you have found a radiation leak, tell the Shelter Manager. A work party should be organized to build a gamma barrier to cover up the leak. If you had the time and opportunity, you should have gathered materials for this purpose before fallout arrived, as discussed in paragraph 4-2b (3.) Work on construction of this barrier should begin as soon as possible, before the radiation climbs to higher levels. The barrier can be improvised from any materials on hand. If you have lumber, nails, and carpenter’s tools available and have hauled piles of earth or sand into the shelter before fallout arrived, you may be able to construct a very good barrier. Stacks of bricks will also make good barriers. If these materials aren’t available, items such as furniture, books, magazines, newspapers, and water containers may be used.

While the barrier is being constructed, do not forget to take the regular readings which tell whether the radiation levels are rising or falling. Write these readings on a piece of paper or on a form as shown in Figure 4-5, and tape or tack it to a wall or post near the place where the reading was made.

After the barrier is constructed, take several measurements of the kind you took to find the leak, to see if the radiation leak has been covered up. If you found the leak by taking a series of measurements from one side of the area to the other, with several people standing closely behind you, you should repeat that kind of measurement. You should be able to tell by these measurements if the barrier has improved the shielding in the leak area, or if more work is required on the barrier. If there is no change in these readings from your earlier readings, there is a possibility that the barrier may have missed the area through which the extra gamma radiation is passing. In this case, more work should be done to locate the leak and construct the barrier.

Again, let us look at Erskine Hall as an example. The shelter sketch is shown in Figure 4-6. In making a detailed survey of Room G, the RM found readings in two places which were 15-30 percent higher than at other places in Room G. One location was by the closet under the stairs and the other location was by the open door to Room F.

The reading by the stair closet was about 15 percent higher than elsewhere. The radiation was assumed to be coming from above, through the stairways. The Shelter Manager, RM, and Unit Leaders decided not to pile material on the stairs because the occupants would then have trouble getting out if there were a fire. Instead, they blocked off an area by the closet and planned to rotate people in and out of that area so the radiation dose would be evenly spread out among people in radiation sensitivity category Y/A, Table 4-1.

The reading by the door to Room F was about 30 percent higher than elsewhere. In the time-averaging readings, Room F (location 5) was found to have a higher reading than the other rooms, as shown in Table 4-2. This higher reading was expected, because in improving the radiation shielding of the shelter, all the windows around the basement had been covered except for two in Room F. Materials were not available to construct baffles around these windows, such as shown in Figure 4-4. Instead, a wall of earth was piled up a few feet away from the window to shield the window against gamma radiation coming from fallout on the ground beyond the earth barrier. It was considered absolutely essential to leave these windows open to provide cooling for the people packed in Room G. Fresh air was coming in from those windows, passing through the open door to Room G, and flowing out the door by the stairs.

After examining the sketch of the floor plan, it was decided that a hole could be knocked in the wallboard partition to allow air to flow between Rooms C and F and the door between Rooms C and G could be left open. The door between Rooms G and F could then be closed and covered with a barrier.

The hole between Rooms C and F was made on the far side from the door by the outside wall, so the gamma rays from the two open corner windows would not have a direct open path to the door between Rooms C and G. The door between Rooms F and G was closed, and a stack of bricks was built in front of it.

These measures reduced the radiation in Room G near the door to Room F to levels that were about the same as elsewhere in the room (except by the stairway closet). Ventilation became much better for the people along the North half of the room, but the people in the hall leading to Room F soon complained about lack of ventilation. The bricks in front of the door to Room F were re-stacked so there were one-to-two inch gaps between the bricks on the bottom four layers. The door was propped open a few inches so air could flow through the gaps left between the bricks. Another wall of bricks, only six layers high, was constructed about six inches back from the door-high stack of bricks, to block off gamma rays coming through the gaps.

e. **Gamma Shielding by People -** In Table 1-2, the human body is listed with a density of 0.4 relative to concrete. The shielding effect of human bodies can be used to provide extra protection. This protection would be of particular benefit to those people with the greatest sensitivity to radiation, namely, children and pregnant women. If the estimated or projected radiation exposures look as if they may become high enough to cause radiation sickness and other ways to decrease or avoid radiation exposure are not possible, this shielding method could be used. It would be expected that this extreme measure of providing shielding would be used only during the first 24 hours after fallout arrives, when the radiation hazard is by far the most severe.

Ordinarily, people in most shelters will be sitting or reclining on the floor most of the time. More gamma radiation will be blocked if the people are standing up, because their bodies will then absorb some of the gamma rays coming from the ceiling as well as those coming from the walls. This shielding, provided by people who are standing, could provide an extra measure of protection for children, mothers with infants, and pregnant women. By forming a two-or-three person deep circle around the more radiation-sensitive occupants of a shelter, these individuals can possibly be spared high radiation exposures that would be especially detrimental to them. The survey meter should be used to find the arrangement of people that provides the best shielding.

Children and infants may be provided additional protection from overhead radiation by placing them underneath beds, desks, tables, or other suitable items. People with less radiation sensitivity may then sit or lie on top to provide additional shielding.

The RM may verify the shielding effect provided by people by reading the survey meter at different levels in the middle of a room full of people who are standing up. In basement shelters, where no gamma radiation comes up through the floor, the survey meter reading at the floor might be as much as ten times lower than the reading at the waist height at the wall. The radiation may even be undetectable at the floor. In high-rise shelters where much of the gamma radiation comes in horizontally through the walls and some comes up at different angles through the floors, this effect won’t be as dramatic.

f. **Keeping Track of Everyone’s Radiation Exposure (Group Dosimetry).** The radiation hazard will be worst throughout the first 24 hours after each fallout cloud arrives. It is important to start keeping track of everyone’s radiation exposure right away, as soon as fallout begins to arrive. In most shelters the radiation levels will be different as you move from one place to another. In these shelters each Unit Leader should have a dosimeter. The readings on the Unit Leader’s dosimeter will be used to fill out the radiation exposure record of each member of the unit. For this reason, every member of the unit should stay close to the leader, especially during the first 24 hours after fallout arrives. This method of estimating individual exposures is called GROUP DISOMETRY.

If any member of the unit needs to make an urgent trip to some area where the radiation level is higher and for a length of time such that the person's radiation exposure might be a few roentgens higher than the rest of the unit, special arrangements should be made. The Shelter Manager and RM should be consulted if the trip is unusual. An extra entry should be made on the individuals radiation exposure record for such trips.

Trips to restrooms and drinking fountains in areas of higher radiation levels should be limited in number and length. The Unit Leader should make about the same number of trips as other unit members at about the same times for the same length of time. The dosimeter should be worn by the Unit Leader on these trips to get an idea of how much exposure is received during these trips. If some members need to make additional trips, the extra exposure should be estimated by the Unit Leader, with help from the RM if necessary, and entered on the members' radiation exposure records.

You, the RM, should very carefully monitor your own exposure and make forecasts on your future exposures so you will not exceed the limit of exposure set in Row A of the Penalty Table (Table 4-3). Your experience and training make you very valuable to the occupants of the shelter.

A dosimeter hung on the wall or a post at eye level or higher will show a higher radiation exposure than a dosimeter carried on a person in the same area. The person's body shields the dosimeter from some of the gamma radiation. If the person wearing the dosimeter is surrounded by many people who are standing up, the reading on that person's dosimeter will be even lower because of the gamma shielding provided by the people's bodies.

During the first 24 hours after fallout begins to come down, entries should be made every 4 hours in each person's radiation exposure record. The Unit Leader should check each entry on each record kept in his unit. The RM should spot-check records throughout the shelter and look for entries which seem too high or too low. Such entries may be due to faulty instruments or to shielding conditions, which the RM should know about. It is important that these situations be corrected as soon as possible.

Sample radiation exposure records from Erskine Hall are shown in Figures 4-7 and 4-8. The radiation exposure record in Figure 4-7 shows what a dosimeter would read if it were mounted at location 1, where survey meter readings were taken for Figure 4-5. The radiation exposure - record taken from dosimeters clipped to the clothing of adults on the edges of Room G would have entries which may be less than 75 per-cent of the entries in Figure 4-7, due to the shielding effect of their own bodies and others. The entries on records of those in the interior of the room would be even lower.

In Figure 4-8 the radiation exposure record is shown for John Doe, an infant. His radiation sensitivity category is "CHILD," as listed in Table 4-1. This record was maintained by his father, James Doe, who was made the leader of the shelter unit in which the Doe family was placed. The radiation levels in Erskine Hall started to climb a second time at 1645 hr on July 5, 1989, as shown by the survey-meter readings in Figure 4-5, indicating the arrival of another cloud of fallout. By 1745 hr the radiation level had reached 5 R/hr at location 1 and was still climbing. It was decided that human body shielding would be used to protect those in the first two radiation sensitivity categories. This special shielding, involving all the people in the shelter, began at 1800 hr, as shown on the radiation exposure records in Figure 4-8, and reduced John Doe's exposure to less than half of what it would have been without this special shielding. On the second day, 24 hours after fallout arrived, special shielding was terminated, but partial shielding for John Doe was provided by the members of his shelter unit. The next 13 entries were made on a daily basis instead of every four hours. On July 18, the occupants of Erskine Hall were relocated to a shelter in an area with much lighter fallout.

4-5. **After Fallout Has Stopped Coming Down**

a. **Forecasting Radiation Exposure**. When the survey meter readings level off and then continue to decrease, the arrival of fallout from that particular cloud at your location has almost ended. If no more fallout clouds arrive, the radiation levels will continue to decrease rapidly.

The highest radiation exposure at a given place in a shelter will accumulate during the first 24 hours after fallout arrives. After these first 24 hours have passed, there are two general rules which can be used to forecast the radiation exposure, as follows:

RULE 1: The radiation exposure at a given place during the entire WEEK following the arrival of fallout is unlikely to be more than 2-1/2 TIMES the exposure during the first 24 hours.

RULE 2: The radiation exposure at a given place during the entire MONTH following the arrival of fallout is unlikely to be more than 3-3/4 TIMES the exposure during the first 24 hours.

RADIATION EXPOSURE RECORD

Name LOCATION 1

Home Address

Social Security No.

Shelter Address ERSKINE HALL

Name of Shelter

Unit Leader

Rad. Sensitivity

Category

Hour and Date	Added Exposure (R)	Total Exposure To Date	Comments
1400 5-7-89	8	8	FALLOUT BEGAN AT [illegible]
1800 5-7-89	14	22	
2200 5-7-89	23	45	
0200 6-7-89	15	60	
0600 6-7-89	12	72	
1000 6-7-89	9	81	END OF FIRST 24 HR
1000 7-7-89	35	116	
1000 8-7-89	19	135	
1000 9-7-89	14	149	
1000 10-7-89	10	159	
1000 11-7-89	8	167	
1000 12-7-89	7	174	END OF FIRST WEEK
1000 13-7-89	6	180	
1000 14-7-89	5	185	
1000 15-7-89	4	189	

FRONT SIDE

Hour and Date	Added Exposure (R)	Total Exposure To Date	Comments
1000 16-7-89	4	193	
1000 17-7-89	3	196	
1000 18-7-89	3	199	SHELTER VACATED
1000 19-7-89	3	202	END OF 2nd WEEK
1000 22-7-89	7	209	
1000 26-7-89	9	218	END OF 3rd WEEK
1000 2-8-89	8	226	END OF FIRST MONTH

BACK SIDE

Figure 4-7. Sample dosimeter readings at location 1 in make-believe Erskine Hall.

RADIATION EXPOSURE RECORD

Name JOHN DOE

Home Address SOMEWHERE, USA

Social Security No. NONE--INFANT

Shelter Address ERSKINE HALL

SOMEWHERE, USA

Name of Shelter

Unit Leader JAMES DOE

Rad. Sensitivity

Category CHILD

Hour and Date	Added Exposure (R)	Total Exposure To Date	Comments
1400 5-7-89	6	6	FALLOUT BEGAN 1009
1800 5-7-89	10	16	SPECIAL SHIELDING BEGUN
2200 5-7-89	7	23	
0200 6-7-89	5	28	
0600 6-7-89	4	32	
1000 6-7-89	3	35	UNIT SHIELDING BEGUN
1000 7-7-89	18	53	
1000 8-7-89	10	63	
1000 9-7-89	7	70	
1000 10-7-89	5	75	
1000 11-7-89	4	79	
1000 12-7-89	3	82	END OF FIRST WEEK
1000 13-7-89	3	85	
1000 14-7-89	3	88	
1000 15-7-89	2	90	

FRONT SIDE

Hour and Date	Added Exposure (R)	Total Exposure To Date	Comments
1000 16-7-89	2	92	
1000 17-7-89	2	94	
1000 18-7-89	2	96	EVACUATED
1200 18-7-89	6	102	TRIP TO SAFERVILLE
1000 19-7-89	—	102	END OF 2nd WEEK
1000 26-7-89	1	103	END OF 3rd WEEK
1000 2-8-89	—	103	END OF FIRST MONTH

BACK SIDE

Figure 4-8. Sample radiation exposure record for the fictitious John Doe, as filled out by his father. The estimated effect of human shielding may be seen by domparing these entries with the readings of an exposed dosimeter shown in Figure 4-7.

If the fallout comes from distant ground bursts and doesn't arrive at your shelter until 24 hours or more after the explosions, the numbers in Rules 1 and 2 may be slightly greater. For example, if the fallout takes about 36 hours to get to your shelter, the number 2-1/2 in Rule 1 will be increased to 3.0 and the number 3-3/4 in Rule 2 will be increased to 4.5.

If the fallout takes about 48 hours to get to your shelter, the corresponding numbers will be increased to about 3-1/3 and 5-1/3, respectively. When the fallout takes a long time to arrive, the radioactivity will have decayed a great deal. If the fallout comes from a large number of ground bursts of large-yield weapons, as might take place on military targets, the fallout may still be hazardous even though it may take 48 hours to arrive at your shelter.

If the fallout comes from closer ground bursts and arrives at your shelter in 12 hours or less after the explosions, the numbers in Rules 1 and 2 will be less. More than half of the total exposure in a week will accumulate in the first 24 hours after fallout arrives. The number 2-1/2 in Rule I will be decreased to between 1-1/2 and 1-3/4, and the number 3-3/4 in Rule 2 will be decreased to between 1-3/4 and 2-1/2.

Exposure forecasts can be made using the seven-ten rule described in paragraph 1-10d when all the fallout is the same age, when the time of the explosion is known fairly well, and when there are no weathering effects. These circumstances are unlikely in a modern, full-scale nuclear war. The Radiological Defense Officer in the local Emergency Operating Center (EOC) may be able to provide further guidance on estimated radiation exposure.

The general rules given above can be used to make forecasts for the possibility of radiation sickness among a group of people in a given shelter. If the radiation exposure of an average adult is 60 R or less at the end of 24 hours after fallout arrives and that person remains in the same place, that person's accumulated radiation exposures will be expected to be less than 150 R in one week and less than 225 R in one month, providing no additional fallout arrives. According to the Penalty Table (Table 4-3), that person should require no medical care in the first week, but the exposure in a month would exceed the limits set in the Penalty Table for not requiring medical care.

If it appears that the radiation exposure of average adults will be more than a pre-selected value, such as 60 R, at the end of the first 24 hours after fallout arrives at the shelter, the local EOC should be notified. Some emergency action may be possible which will reduce the accumulated radiation exposure and thus prevent radiation sickness among these people.

Again, let us look at the made-up example provided by Erskine Hall. The radiation exposure record for a dosimeter mounted at location 1 is shown in Figure 4-7, and the survey-meter readings for that location are shown in Figure 4-5. The first detection of fallout was made outside the shelter at 1009 hr on July 5. It was estimated that this fallout resulted from many large-yield ground bursts on military targets about 250 km (150 miles) upwind during the night before, at around 2100 hr on July 4. The radiation level from this fallout reached a maximum value at around 1330 hr on July 5, indicating that most of the fallout destined for Erskine Hall from these explosions had reached the ground by this time. The fallout took 13 hours to reach Erskine Hall. It kept coming down for about 3-1/2 hours.

A distant explosion was heard at 1500 hr on July 5, in the direction of a city located about 50 km (30 miles) upwind. The fallout from this explosion began to arrive at Erskine Hall at about 1645 hr, an hour and 45 minutes after the explosion was heard. This fallout was more radioactive than the older fallout from the distant explosions. Being fresher, it would decay faster. This fallout kept coming down for about 2-1/2 hours and added to the radiation levels, which were already there from the older fallout.

At the end of the first 24 hours after fallout arrived, at 1000 hr on July 6, the accumulated radiation exposure by the dosimeter at location 1 was 81 R, as shown in Figure 4-7. After one week, the accumulated radiation exposure was 174 R, 2.15 times the exposure during the first 24 hours. After one month, it was 226 R, 2.79 times the exposure during the first 24 hours.

b**. The Penalty Table**. An adult will not normally need medical care when the whole body is exposed to the quantities of radiation listed in Row A of Table 4-3 if the exposure is spread out over the listed periods of time. Rows B and C are intended to be used for making decisions on performing urgent missions, which may involve the risk of increased radiation exposure.

Each person can tolerate a certain amount of sunshine on bare skin in an afternoon without getting painful sunburn. Similarly, each person can be exposed to a certain amount of whole-body gamma radiation within a certain period of time without getting sick. The Penalty Table (see Table 4-3) shows in row A what exposures might be received by an average adult without requiring medical care, when the exposure is spread out over different periods of time. Infants, small children, and pregnant women should be given special consideration when possible, because they are more likely to have radiation sickness at lower levels of radiation exposure than other individuals of the general population.

Table 4-3. The penalty table[a/]

Medical care will be needed by--	Accumulated radiation exposure (R) in any period of a One week	b One month	c Four months
A NONE	150	200	300
B SOME (5 percent may die)	250	350	500
C MOST (50 percent may die)	450	600	---

[a/]This table is taken from Radiological Factors Affecting Decision-Making in a Nuclear Attack, National Council on Radiation Protection and Measurements, Report No. 42.

For most shelter occupants, the exposures in row A should not be exceeded. If the radiation levels reach 10 R/hr in the shelter and continue to climb, it is possible that the accumulated exposure in one week will be greater than 150 R. In this case, the local EOC should be notified. Some emergency action may be possible which will reduce the accumulated radiation exposure and thus prevent radiation sickness in the shelter.

c. **Use of the Penalty Table as a Guide for Operations -** The Penalty Table was developed to provide a simple guide when decisions must be made that will involve some risk. The choice of the numbers was based on judgment derived from extensive clinical radiotherapy experience, pathological studies of radiation-accident victims, and laboratory experience with numerous large and small animals. There is no directly applicable disaster or laboratory experience involving humans that clearly supports the choice of all of the numbers in the Penalty Table. There is also no satisfactory biological model or mathematical formula relating radiation effects (of the type considered here) to exposure rates and durations that provides a satisfactory basis for deriving the amounts of exposure indicated in the table for time periods greater than one day. These are the best numbers available at the present time for this purpose.

Three Examples of the Penalty Table are given here:

Example 1. It would be best if everyone's radiation exposure could be kept as low as possible, but due to wartime conditions, some individuals may have to spend some time in areas of higher radiation levels. Suppose you are trying to limit their radiation exposures to levels resulting in low risk. Th numbers in Row A of Table 4-3 apply in this case. According to these numbers, it would be necessary to limit the total radiation exposure of individuals to less than 150 R in any one week (column a), 200 R in any one month (column b), and 300 R in any four-month period (column c).

For example, if individuals were exposed to the one-week limit of 150 R (column a) within the first week, then the limit for additional exposure during the following three weeks of the first month, to keep within the one-month limit (column b) would be 200 R - 150 R = 50 R. This additional exposure of 50 R could be received at any rate (for example, by going outside the shelter into areas of higher radioactivity) during the following three weeks of the first month, without exceeding the one-week or one-month limits in the Penalty Table. However, if this additional exposure of 50 R were received, for example, within the second week, then the individuals would have to be kept completely free of further exposure (which may not be possible) during the remainder of the first month to keep within the one-month limit for Row A (200 R). Similarly, if the individuals were exposed to the limit of 200 R in the first month, without exceeding 150 R in any one week of that month, the limit of additional exposure for the following three months of the first four months (column c) would be 100 R, for a total of 300 R (200 R + 100 R) in four months.

Example 2. Suppose you need to conduct operations at the intermediate level of radiation exposure, involving significant medical risk (Row B), justified by highly critical emergency situations. The decision to conduct such operations must involve the Shelter Manager.

In this case, the decision-maker may find it necessary to allow greater exposure than one or another of the limits indicated in Row A but would be constrained whenever possible by other limits in Row A and always by limits in Row B of the Penalty Table.

For example, if individuals who have been exposed to 150 R within the first week are required in some emergency to be exposed to an additional 200 R during the remainder of the first month (for a total of 350 R in the first month), it is desirable, if possible, that the one-week constraint for Row A (column a) be observed by allowing no more than 150 R of this additional exposure during any one week within that month, even though the one-month limit (200 R) and four-month limit (300 R) for Row A will have been exceeded and the one-month limit (350 R) for Row B will have been reached. If it is not possible to keep within any of the constraints for Row A, then the Row B constraints have to be applied. In other words, you try to keep exposure in any one week as far as possible below 250 R and to limit the exposure during the first month to 350 R. Any additional exposure after this first month must be kept as far as possible below the additional 150 R which would attain the four-month limit of 500 R (Row B).

As in example 1, the decision-maker could schedule exposures in a variety of ways within the constraining limits to meet the work required by the problem at hand.

Example 3. Suppose you need to conduct operations at the high levels of medical risk (Row C), justified only by extremely critical emergency situations. Again the decision to conduct such operations must involve the Shelter Manager. Those activities that could result in saving a significant number of lives may call for the deliberate exposure of some persons at the highest constraint levels, where radiation sickness and a 50 percent probability of death are expected (Row C). If such situations arise, the decision-makers would use for guidance Row C of the table in a manner similar to that discussed for the low- and intermediate-risk rows (A and B) in examples 1 and 2.

After a time of no more than two weeks, it should be possible to move people from areas of high radiation levels to areas of lower radiation levels. In the areas of lower radiation levels, people should be able to get outside and work for different lengths of time as long as their radiation exposures stay within the limits of Row A of the Penalty Table. The "one-month" and "four-month" columns of the Penalty Table are intended primarily for these situations. No one should have to stay totally confined inside the shelters for more than two weeks, although people may have to live in them in some locations for longer periods.

d. **Checking Radiation Levels Beyond the Immediate Shelter Area -** Sometime no later than 24-30 hours after fallout has begun to come down., you (the RM) should take the survey meter and check the radiation levels in rooms next to the shelter area and on the way to the outside. The purpose of this exploration is to get an idea how dangerous the levels are outside the immediate shelter area, to estimate the risks in emergency operations, and to forecast when people could leave the shelter for short periods and when they could move to safer areas if needed.

Your experience and training make you very valuable to the occupants of the shelter. You should very carefully monitor your own exposure and make forecasts on future exposures so you will not exceed the limit of exposure set in Row A of the Penalty Table.

If you used the time-averaging method to find the safest location in the shelter and the fallout pattern hasn't been shifted by wind or rain, you may use the results of those measurements to estimate the radiation levels in the other rooms which you checked, by using the RATIO METHOD. Suppose you stayed near location 1, your "home base," during the first 24 hours after fallout arrived. Now you want to find out how high the radiation level is at location 5. Suppose you included location 5 in your time-average comparison. Then you can estimate the present reading at location 5 by first finding the ratio of the time average reading at location 5 to the time-average reading at location 1. Then multiply this ratio times the current reading at location 1 to get the current reading at location 5. In other words, The current reading at location #5 equals the Time-average reading at location #5 divided by the Time-average reading at location #1, multiplied by the Current reading at location #1.

The measurements at Erskine Hall will be used as an example. Suppose we would like to know what the survey-meter reading would be at location 5 in Erskine Hall at 2000 hr on July 5, without actually taking the survey meter to the location. We have been making measurements regularly at location 1, as shown in Figure 4-7. We have the set of time-average measurements that were made earlier for seven locations, including locations 1 and 5, as listed in Table 4-2. To get the current reading (at 2000 hr) at location 5 without taking a survey meter to that location, the following steps are taken:

(1) The current reading (at 2000 hr) at location 1 is found to be 6.0 R/hr.

(2) The time-average reading at location 5 was 1.435 R/hr.

(3) The time-average reading at location 1 was 0.575 R/hr.

(4) The ratio of the time-average reading at location 5 to the time-average reading at location 1 is 1.435/0.575 = 2.5.

(5) The current reading at location 5 is estimated by multiplying the ratio obtained in step (4) times the current reading at location 1, which yields 2.5 x 6.0 = 15 R/hr.

If more than one set of time-averaging measurements has been made, be sure to calculate the ratio with readings that were made in the same set of measurements.

Once the ratio of the time-average readings has been calculated, that same ratio can be used to estimate the reading at the remote location at any other time, assuming that the fallout pattern hasn't been shifted by rain or wind. For example, the estimated reading at location 5 in Erskine Hall at 2100 hr would be 2.5 times the reading at location 1 at that time, which is 5.5. The estimated reading at location 5 at 2100 hr would be 2.5 x 5.5 = 13.75 R/hr.

You may use the ratio method to estimate the radiation levels; first, at various strategic locations inside your shelter building and, later, at various locations outside your building. First take a reading at your home-base location. Then take the survey meter (wear a dosimeter) to the strategic location and take a reading there. You will not need to use the time-average method after 24 hours after the last particles of fallout have arrived because the radiation levels will be decreasing slower than 1 percent per minute. The ratio of the reading at the strategic location to the reading at the home base can be used to estimate readings at the strategic location by multiplying that ratio times the home-base readings.

As an example, the RM at Erskine Hall measured 2.1 R/hr at location 1, the home base, at 1000 hr on July 6. The RM took the survey meter up the stairs and made a quick trip into the lobby of Erskine Hall, where the survey-meter reading was 85 R/hr. The ratio of the lobby to home-base reading was 40. By 1000 hr on July 7, the home-base reading was 1 R/hr. The ratio of 40 was used to estimate that the radiation level in the lobby at that time was 40 R/hr.

At that time the RM took the survey meter upstairs and out to the street in front of Erskine Hall, where he measured a radiation level of 105 R/hr. His dosimeter showed an increase of 2 R for this trip, which he made as quickly as possible. The street to home-base ratio of readings was thus determined to be 105.

e. **Leaving the Shelter -** When the exposure rates outside the shelter are known, Table 4-4 may De used as a general guide for permissible activities. Decisions on how much exposure may be allowed should be based strictly on the Penalty Table. Unit Leaders should continue to keep close track of the radiation exposure of each member until shelter is no longer required. If the shelter is vacated and people are moved to other shelters, it would be preferable if units remained together. Exposure records must go with the individuals to whom they belong.

If the fallout is relatively young (two or three hours since fallout stopped coming down) and the radiation levels are decaying rapidly, greater relaxation of shelter control can be tolerated than indicated in Table 4-4. Conversely, if the fallout is relatively old (several days or weeks), more rigid control would be required.

Table 4-4. General guide for permissible activities outside the shelter

If the outside exposure rate (R/hr) is	Permissible activities
More than 100	Outdoor activity may result in sickness or death. Occasions which might call for outside activity are (1) risk of death or serious injury in present shelter from fire, collapse, thirst, etc., and (2) present shelter is greatly inadequate--might result in fatalities--and better shelter, available for occupancy, is known to be only a few minutes away.
10-100	Time outside of the shelter should be held to a few minutes and limited to those few activities that cannot be postponed. All people should remain in the best available shelter no matter how uncomfortable.
2-10	Periods of less than an hour per day of outdoor activity are acceptable for the most essential purposes. Shelter occupants should rotate outdoor tasks to distribute exposures. Outdoor activities of children should be limited to no more than 10 to 15 minutes per day. Activities such as repair or exercise may take place in less than optimum shelter.
0.5-2	Outdoor activity (up to a few hours per day) is acceptable for essential purposes such as fire fighting, police action, rescue, repair, securing necessary food, water, medicine, and blankets, important communication, disposal of waste, exercise, and obtaining fresh air. Eat, sleep, and carry on all other activities in the best available shelter.
Less than 0.5	No special precautions are necessary for operational activities. Keep fallout from contaminating people. Sleep in the shelter. Always avoid unnecessary exposure to radiation.

Appendix A
GLOSSARY

The meanings of some of the specialized words and abbreviations used in this handbook are provided in this list, which is arranged alphabetically.

absorbed dose - the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest. The unit of absorbed dose is the Rad.

air burst - the explosion of a nuclear weapon at such a height that the fireball does not touch the earth's surface. Fallout from an air burst is negligible.

alpha particle - a positively charged nuclear particle identical with a nucleus of a helium atom that consists of two protons and two neutrons and is ejected at high speed from the nucleus of certain atoms in radioactive decay processes.

alpha radiation - rays of alpha particles.

alpha ray - an alpha particle moving at high speed, or a stream of such particles.

atom - the smallest particle of an element that still retains the characteristics of that element. Every atom consists of a positively charged central nucleus, which carries nearly all the mass of the atom, surrounded by a number of negatively charged electrons, so that the whole system is normally electrically neutral.

background radiation - nuclear radiations arising from within the body and from the surroundings to which individuals are always exposed. The main sources of the natural background radiation are potassium-40 in the body, potassium-40, thorium, uranium, and their decay products present in rocks and soil, and cosmic rays.

beta burn - damage to the skin caused by prolonged contact with particles that emit beta radiation.

beta particle - an electron (negatively charged particle) or a positron [positively charged particle] ejected at high speed from the nucleus of certain atoms in radioactive decay processes.

beta ray - a beta particle moving at high speed, or a stream of such particles.

beta radiation - rays of beta particles.

blast wave - a violent pulse of air in which the pressure increases sharply at the front, accompanied by winds, propagated from an explosion.

bone seeker - any compound or ion that migrates in the body preferentially into bone.

contamination - the deposit of radioactive materials on the surfaces of structures, areas, objects, or personnel.

cumulative dose - the total dose resulting from continued or repeated exposures to radiation.

curie [abbreviated as Ci] - unit of radioactivity equal to 3.7 x 10 to the tenth power disintegrations per second.

decontamination - the removal of radioactive material from a structure, area, object, or person, or the reduction of radiation from a surface or area by covering it.

dose - a general term indicating the quantity of radiation or energy absorbed.

dose equivalent [abbreviated as DE] **-** a quantity that is related to the expected detriment resulting from exposure to any kind of nuclear radiation, defined as the product of the absorbed dose in rads and modifying factors; the unit of DE is the rem.

dose rate - absorbed dose delivered per unit time.

dosimeter - an instrument for measuring accumulated exposure to nuclear radiation.

dosimetry - the theory and application of the principles and techniques involved in the measurement and recording of radiation doses and dose rates. Its practical aspect is concerned with the use of various types of radiation instruments with which measurements are made.

electron - an elementary particle having a negative electric charge of 1.6 x 10-19 coulomb and a rest mass 1/1836 that of the proton. In atoms, electrons surround the positively charged nucleus.

element - one of the known chemical substances that cannot be divided into simpler substances by chemical means.

emergency services - elements of government that are responsible for the protection of life and property, such as fire, police, welfare, and rescue services.

EOC - (Emergency Operating Center) - a well-protected headquarters at various levels of government, such as city, county, state, or region, with two-way radio and telephone communications with shelters, emergency services, other EOCs, and various government headquarters.

exposure - a quantitative measure of gamma or x-ray radiation at a certain place, based on its ability to produce ionization in air, measured in units of roentgens.

fallout - the process of the settling to the earth's surface of airborne particles containing radioactive material following a nuclear explosion; also refers to the particles themselves.
Early fallout, also called local fallout, is that fallout which settles to the surface of the earth during the first 24 hours after a nuclear explosion.
Delayed fallout, also called worldwide fallout, is that fallout which settles to the surface of the earth at some time later than the first 24 hours after a nuclear explosion. Most of the fallout from a surface burst will be deposited within 24 hours after a nuclear explosion and within 400 to 500 miles downwind from the explosion.

fallout half-value thickness - the thickness of a given material which will absorb half the gamma radiation incident upon it. This thickness depends on the nature of the material…it is roughly inversely proportional to its density…and also to the energy of the gamma rays. These factors are specially calculated for fallout radiation and include all processes of attenuation of radiation.

fallout protection factor [FPF] - an indication of the degree of protection provided by a location against gamma radiation from fallout. The FPF for a location is defined as the ratio of the radiation exposure rate at 3 feet above a flat, smooth, large, open area to the radiation exposure rate at the location in question, when the same amount of fallout is deposited uniformly over both locations. If the FPF of a location is one, that location provides no protection against gamma radiation. This factor is also called the protection factor (PF) . It is called "fallout protection factor" in this handbook because "protection factor" can mislead people into thinking that a location with a high "protection factor" will also protect against blast and thermal radiation.

fallout shelter - an enclosed area or place which can provide refuge and protection against fallout radiation by absorbing some or most of the radiation directed toward the shelter.

fireball - the luminous sphere of hot gases which forms a few millionths of a second after a nuclear explosion as a result of the absorption by the surrounding air of the radiation emitted by the extremely hot weapon residues. The exterior of the fireball is initially sharply defined by the luminous shock front and later by the hot gases themselves and may be visible for several minutes.

fission fraction - the fraction (or percentage) of the total yield of a nuclear weapon which is due to fission, the remaining fraction of the yield being due to fusion. For thermonuclear weapons the average value of the fission fraction is about 50 percent.

fission, nuclear - a nuclear transformation characterized by the splitting of a high-mass nucleus into at least two other nuclei of lower mass and the conversion of some of the initial mass into a relatively large amount of energy.

fission products - a general term for the complex mixture of substances produced as a result of nuclear fission. About 80 different fission fragments result from approximately 40 different modes of fission. The fission fragments, being radioactive, immediately begin to decay, forming additional (daughter) products, with the result that the complex mixture of fission products so formed contains over 300 different isotopes of 36 elements.

FPF - see fallout protection factor.

fusion, nuclear - a nuclear transformation characterized by the uniting together of two or more low-mass nuclei into a nucleus of higher mass and the conversion of some of the initial mass into a relatively large amount of energy.

gamma radiation - rays of high-energy photons from radioactive material.

gamma ray - a photon of high energy, or a stream of such photons, emitted by the nuclei of certain atoms during the radioactive decay process.

ground burst - a nuclear detonation at the surface of the earth, or at such a height above the earth that the fireball makes contact with the surface.

ground zero - the point on the surface of the earth vertically below, at, or above the point at which a nuclear explosion is initiated.

group dosimetry - a method for estimating radiation exposures of individual members of a group when there aren't enough dosimeters for each member to have one.

half-life (radioactive half-life) - the time in which half the atoms of a particular substance undergo radioactive decay.

high-risk areas - geographical areas in the United States estimated to be subject to a 50 percent or greater probability of receiving blast overpressures of 2 psi or more in a nuclear war, or to a 50 percent or greater probability of receiving a radiation exposure of 100 R or more.

hot spot - a localized surface area of higher than average radiation.

initial nuclear radiation - nuclear radiation (essentially neutrons and gammas) emitted from the fireball and the cloud column during the first minute after a nuclear explosion. The time limit of one minute is set somewhat arbitrarily as that required for the source of the nuclear radiations to attain such a height that only insignificant amounts of radiation reach the earth's surface.

ion - an atom or molecule that has lost or gained one or more electrons to become electrically charged.

ionization - the process of adding electrons to or removing electrons from atoms or molecules.

isotopes - forms of the same element having identical chemical properties but differing in their atomic masses due to different numbers of neutrons in their respective nuclei and also differing in their nuclear properties, such as half-life, energy, and type of nuclear radiation emitted.

kiloton energy - approximately the amount of energy that would be released by the explosion of 1000 tons of TNT, defined precisely as 10 to the 12^{th} power - calories, or 4.19 x 10 to the 19^{th} power - ergs.

latency or latent period - the period of time between exposure to radiation and the detection of a specified effect of that exposure; or, for acute radiation sickness, the time during which no symptoms appear between the first reaction to radiation exposure and the later radiation sickness.

lethal radiation dose - the total-body radiation exposure required to cause death in 100 percent of a large group of people within a specified time period. For example, LD100/60 indicates a dose which is lethal to 100 percent of the people exposed within 60 days after the exposure.

megaton energy - approximately the amount of energy that would be released by the explosion of one million tons of TNT, defined precisely as 10 to the 15^{th} power - calories, or 4.19 x 10 to the 22^{nd} power - ergs.

midlethal or median lethal radiation dose - the short-term, total-body radiation exposure to cause death in 50 percent of a large group of people within a specified time period. For example, LD50/60 indicates a dose which is lethal to 50 percent of the people exposed within 60 days after the exposure.

milliroentgen (mR) - $1/1000^{th}$ of a roentgen. 1000 milliroentgen equals one roentgen.

neutron - an elementary particle having no electric charge and a rest mass o 1.675 x 10-27 kilogram. The neutron is a constituent of the nucleus of every atom heavier than ordinary hydrogen.

nuclear radiation - particulate and electromagnetic radiation emitted from atomic nuclei in various nuclear processes. The important nuclear radiations, from the weapons standpoint, are alpha and beta particles, gamma rays, and neutrons. All nuclear radiations are ionizing radiations, but the reverse is not true; X rays and nearly all ultraviolet radiation, for example, are included among ionizing radiations, but they are not nuclear radiations since they do not originate from atomic nuclei.

nuclear weapon - any weapon which attains its energy release from the fission or fusion of atomic nuclei.

nucleus - the positively charged central portion of an atom, composed of protons and neutrons and containing almost all of the mass of an atom but only a tiny part of its volume.

overpressure - the transient pressure, usually expressed in pounds per square inch, exceeding the ambient pressure, in the shock (or blast) wave from an explosion. The variation of the overpressure with time depends on the yield of the explosion, the distance from the point of burst, and the medium, whether air, water, or soil, in which the weapon is detonated. The peak overpressure is the maximum value of the overpressure at a given location and is generally experienced at the instant the shock (or blast) wave reaches that location.

photon - a packet of electromagnetic energy having zero mass and no electric charge. Visible light is made up of low-energy photons, and gamma rays are high-energy photons.

protection factor (PF) - this factor is called "fallout protection factor" in this handbook and is defined under that name. The term "protection factor" can mislead people into thinking that a shelter with a high protection factor will provide protection against blast.

proton - an elementary particle having a positive electric charge numerically equal to that of the electron and a mass of 1.672 x 10-27 kilogram. The proton constitutes the nucleus of the hydrogen atom and is a part of the nucleus of every atom.

rad - a special unit of absorbed dose equal to 100 ergs of energy imparted by ionizing radiation per gram of absorbing material, such as body tissue. The exposure rate measured at a point in roentgens/hr may be taken to be numerically equal to the absorbed dose rate in rad/hr at that point for external sources of gamma radiation.

radioactive decay - a spontaneous nuclear transformation in which a nucleus emits alpha or beta particles, often accompanied by gamma radiation, resulting in a progressive decrease in the number of radioactive atoms in a substance.

radioactivity - the spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nuclei of an unstable isotope. As a result of this emission the radioactive isotope is converted (or decays) into the isotope of a different daughter element, which may or may not also be radioactive. Ultimately, as a result of one or more stages of radioactive decay, a stable, non-radioactive end product is formed.

rainout - the process of removal of particles of fallout from the air either by the formation of water droplets around the particles which then fall as rain, or by rain falling into the fallout cloud and "washing" the particles down to earth. Rainout does not affect fallout particles that are higher than about 10 km (33,000 ft).

rem - a unit of dose equivalent, numerically equal to the dose in rads multiplied by factors such as the quality factor, which takes into account the higher risk of late biological effects by certain radiations such as heavy ionizing particles (alphas, neutrons, protons) along their paths through cells of the body.

RM (radiological monitor) - the person who uses radiological instruments to (1) measure nuclear radiation intensities, (2) estimate the radiation exposure of shelter occupants, (3) find the places with the lowest nuclear radiation levels in a shelter, (4) advise on the improvement of radiation protection in a shelter, (5) advise when (and for how long) someone can go outside the shelter on short emergency trips, and (6) advise when to leave for longer trips, and when to leave permanently.

roentgen (R) - A unit of radiation exposure determined by the amount of ionization produced in air. Specifically, it has been defined as the quantity of radiation that will ionize dry air at zero degrees centigrade and standard atmospheric pressure to produce one electrostatic unit of electric charge of each sign, both positive and negative, in one cubic centimeter.

shielding - any material or obstruction which absorbs or attenuates radiation and thus protects personnel or materials from the radiation effects of a nuclear explosion. A moderately thick layer of any opaque material will provide satisfactory shielding from thermal radiation, but a considerable thickness of material of high density may be needed to protect adequately from nuclear radiation.

skyshine - radiation, particularly gamma rays from a nuclear explosion or from fallout, reaching a target from many directions, mostly from above, as a result of scattering by air.

surface burst - the same as a ground burst.

survey meter - an instrument used to measure the exposure rate in roentgens per hour at the location being metered.

tenth-value thickness - the thickness of a given material which will decrease the intensity of gamma radiation to one-tenth of the amount incident upon it. Two tenth-value thickness' will reduce the intensity received by a factor of 10 x 10, or 100, and so on. The tenth-value thickness of a given material depends on the gamma-ray energy, but for radiation of a particular energy it is roughly inversely proportional to the density of the material.

thermonuclear - an adjective referring to the process in which very high temperatures are used to bring about the fusion of light nuclei, such as those of the hydrogen isotopes deuterium and tritium, with the accompanying liberation of energy. A thermonuclear bomb is a weapon in which part of the explosion energy results from thermonuclear fusion reactions. The high temperatures required are obtained in this case by means of a fission explosion.

x ray - a photon of high energy, or a stream of such photons, resulting from processes other than nuclear transformations.

yield - the total effective energy released in a nuclear explosion. I t is usually expressed in terms of the equivalent tonnage of TNT that would be required to produce the same energy release in an explosion.

Appendix B

CONVERSION OF STANDARD TIME DESIGNATION TO TWENTY-FOUR HOUR TIME

In twenty-four hour time, used by airlines and military services, the first two numbers indicate the hours past midnight, starting from zero at midnight and going to 24 throughout the 24 hours of the day. The last two numbers in twenty-four hour time indicate the numbers past the hour.

Standard Time	24-hr Time
12:00 AM (midnight)	0000 hr or 2400 hr
12:30 AM	0030 hr
1:00 AM	0100 hr
1:30 AM	0130 hr
2:00 AM	0200 hr
3:00 AM	0300 hr
4:00 AM	0400 hr
5:00 AM	0500 hr
6:00 AM	0600 hr
7:00 AM	0700 hr
8:00 AM	0800 hr
9:00 AM	0900 hr
10:00 AM	1000 hr
11:00 AM	1100 hr
11:59 AM	1159 hr
12:00 PM (noon)	1200 hr
12:30 PM	1230 hr
1:00 PM	1300 hr
2:00 PM	1400 hr
3:00 PM	1500 hr
4:00 PM	1600 hr
5:00 PM	1700 hr
6:00 PM	1800 hr
7:00 PM	1900 hr
8:00 PM	2000 hr
9:00 PM	2100 hr
10:00 PM	2200 hr
11:00 PM	2300 hr
11:59 PM	2359 hr
12:00 AM (midnight)	2400 hr or 0000 hr

Appendix C

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