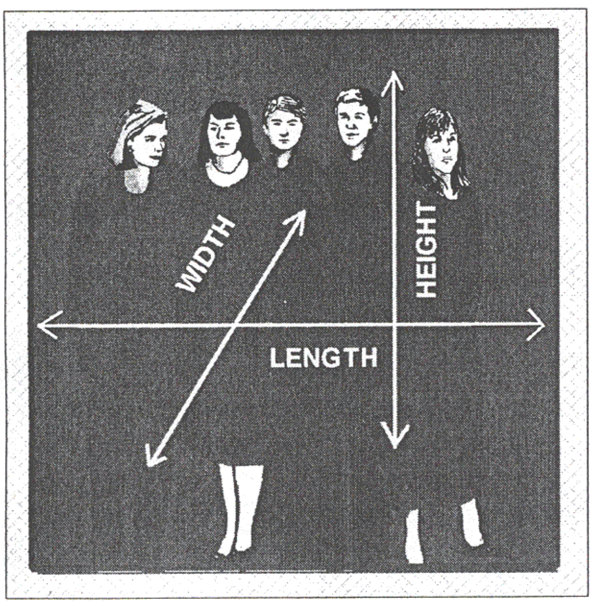
Chapter 22

Shelter Design and Construction Considerations

A shelter project, like any other project, can seem overwhelming at the onset. A large, intimidating shelter project can be tamed by segmenting the project into smaller manageable units such as the shell, air system, power system, lighting system, water supply, etc. Deal with the project a segment at a time. And remember, what man can conceive and believe, man can achieve.

Space Requirements



Space requirements for shelter occupants should be considered from both a basis of square footage per person and cubic feet per person. The U.S. Government publications recommend a minimum of net 10 square feet per person. Net square feet is floor space that can also include walls, bunks, storage and fixed equipment. Try living in 10 square feet for two weeks, especially with children. What if it ends up being 60 or 90 days? Some of the larger shelters I am aware of have up to 50 net square feet per person.

Design Specification Questions

The following are questions, which when answered, can stimulate creative thinking and bring to light considerations that the first time shelter builder may have overlooked.

1. How many people is the project going to accommodate?
2. How many family groups does the above number of people represent and what sizes are these groups?
3. Do you want private rooms for family groups?
4. Where, generally, is the shelter going to be located?
5. Do you want blast protection or do you want fallout protection?
6. How long do you want to be able to remain in the shelter without having to come out? One month, two months, three months, nine months, or more?

7. How much of a food supply do you need to stockpile in or near the shelter? One month supply, two months, six months, one year, or more?

8. Do you want a separate clinic room in the facility?

9. Do you want to try to shield your sensitive electronic equipment from electromagnetic pulse?

10. Do you intend on having communication equipment, (i.e. shortwave, ham, etc.)?

11. Do you intend on having a decontamination area?

12. Do you plan on having a crawl-in or a walk-in entry way?

13. How deep are the wells in the area where the shelter is going to be built?

14. Do you want a pressurized water system with an electric well pump or do you want a hand pump or both?

15. Do you want hot water and flush toilets?

16. Do you want both a men's and a women's bathroom, or one bathroom?

17. Do you plan on having a water storage cistern?

18. How big of a cistern, in terms of balloon capacity, do you want or need?

19. How long do you want to be able to run your generators, (i.e. how long do you want the fuel to last)?

20. Do you want to have an extra generator for back up?

21. Do you want to incorporate the ability to run on battery power into the shelter's power system?

22. Do you want battery power as an emergency reserve or as a primary operating source?

23. How long do you want to be able to run on battery power without recharging the batteries?

24. Is the site for the shelter such that the shelter can be built into the side or into the top of a slope?

25. Are you concerned about the security of your shelter in the event of an emergency occupation?

26. Do you want to have an observation tower incorporated into your shelter which would enable you to have some control of the perimeter around the shelter site?

27. Is the shelter going to be connected to or part of any above ground structure?

You probably don't have the answers to many of these questions but hopefully they have caused you to consider some important aspects of shelter building that you hadn't thought of before.

Site Location Considerations

Proximity to Target Areas

When standing on railroad tracks, if you observe an oncoming train, the logical thing is to get out of the way. If you believe in the possibility of an oncoming nuclear war or natural disaster, the logical thing to do is to relocate out of any target areas or any potential area that could be drastically affected by earth changes. If you live in the crime dominated inner city, what would be a better investment: buying bullet proof vests for your family or moving to a better neighborhood? In the same fashion, building a blast shelter because you live near a known target area, might not be as smart as moving to a non-target area (perhaps as little as ten miles away) and building a less expensive fallout shelter. When you see a locomotive coming down the tracks toward you, the most cost-effective thing you can do is get out of the way.

In order to be effective, shelters in target areas must be blast hardened; built to withstand the direct effects of a nuclear weapon. Even if you have a blast shelter, your first indication of a threat might be the flash of a strike. At that point, it is too late to run to your shelter.

It is my personal opinion that if you determine that you need blast protection, you should seriously consider relocating. Distancing yourself from target areas and areas of vulnerability has both practical and financial advantages. It is practical in the sense of avoiding the direct effects of a nuclear weapon and financial because building a fall out shelter is less expensive than building a blast shelter. Living close to a target area greatly reduces your chance of survival and greatly increases the cost of a shelter.

The best place to relocate to is a remote area, at least ten miles from any target area, and preferably, thirty miles away from any areas of major population. It would be ideal if this area was in proximity to other like-minded people.

Once a decision is made on a general location of a shelter there are certain factors which should be considered for specific locations.

Available Water

You can't live long without water. You should investigate how deep the wells are in the areas you are contemplating for a shelter and how many gallons per minute they produce. Water capability is an important issue. Drilling a 600 or 800 ft. well is expensive, and in the event of well pump failure, it is hard to pull up and service the pump. It is impossible to pump water with a hand pump from a well deeper than 250 feet.

I would highly recommend having a well for your shelter as water is very difficult to store over a long period of time. This subject is covered extensively in the water chapter earlier in this book.

Drainage

Drainage is very important. Consideration should be given not only for a high water table and its obvious complications, but also for the potential impact of unusual surface water runoff which could swamp the shelter.

Depth of Bedrock

It is wise to drill or dig a test hole to determine if there is any underlying bedrock that would obstruct the excavation necessary to accommodate the shelter. I know one shelter project in particular which spent considerable sums of money having to blast through unexpected bedrock.

Tactical Problems

It is ideal if the terrain around a potential shelter site enhances the security of the shelter's perimeter. In other words, it would be best to locate the shelter on a relatively high point which would give its observation tower unobstructed tactical view of the area surrounding the shelter.

Access

Access is a two-edged sword. Too easy an access is not good because you don't want to be constructing your shelter under everyone's gaze and inspection. And you don't want to make it easy for someone not invited to make their way to your shelter. On the other hand, you want to be able to get to it in the winter if needs be. It won't be much good having a shelter you can't get to in time, even if it is an ideal tactical location. Another consideration relating to access is getting equipment and material to the site during the construction phase.

Earthquake Considerations

Buried structures have the advantage of being earth-integrated. In an earthquake, the ground accelerates causing structures above the ground to move back and forth in a rocking motion. On the other hand, structures buried in the earth are moved only slightly and then in sync with the surrounding ground. This can be compared to the way a ship tosses and rolls in a storm on the water's surface and a submarine below the surface moves stably within the sea.

You obviously do not want to build a shelter in close proximity to a known fault, but in general, a buried shelter has the best chance of surviving an earthquake, far better than any type of above ground structure. Nevertheless, shaking will occur. Supplies and equipment on shelves, generators, and water and fuel storage tanks should be properly secured.

Other Shelter Building Considerations

Cutting Into A Used Fuel Tank

D A N G E R

Extreme caution should be exercised when cutting into a used fuel tank. Over the years, numerous people have been killed by explosions resulting from trying to cut a hole in a used fuel tank. Tanks which contained diesel fuel are less susceptible to explosion than tanks which held gasoline. Old gasoline tanks are extremely dangerous to cut into. Regardless if it is an old diesel tank or an old gasoline tank, treat both kinds as if they were gas tanks. You can never be sure exactly what was in the tank.

A fuel tank does not need to have fuel in the bottom of it to be dangerous. The fuel vapors or fumes, mixed with air, will be ignited by a spark from a metal cutting saw or torch. The intensity of such an explosion can rarely be survived.

There are three ways to prevent fuel tank explosions when cutting into a tank. The first is to use dry ice, the second is to use compressed $C0_2$ and the third is to use exhaust off the tail pipe of a truck. The whole concept is to displace the vapor fumes out of the tank with $C0_2$ which is a heavy gas. Begin by making sure the tank is standing upright in its natural position. Then, open one of the plumbing access fittings on the top of the tank.

If using dry ice, put 20 lb. of the dry ice in the tank for each 1000 gallons of tank capacity. The temperature has to be warm enough to facilitate the melting of the dry ice in order to produce the CO_2 gas. Wait until the dry ice has melted completely before cutting into the tank.

If using CO_2 compressed gas, insert a discharge tube from the tank of CO_2 into the access hole in the fuel tank and slowly let the gas fill the tank. Use 150 cu. ft. of compressed CO_2 gas for every 1000 gallons of tank capacity.

When using the exhaust from a truck you need a connecting piece of black flexible PVC waterline slightly larger than the exhaust pipe. Slip this waterline over the exhaust pipe and secure it with duct tape or a hose clamp so that no exhaust leaks out. Put the other end into the access hole in the top of the fuel tank. Turn on the engine and let the truck idle. Check the end of the water line to make sure the exhaust is coming out. Don't use a truck with holes in the muffler. The exhaust contains CO_2 gas which will displace the gas vapors out the top of the access hole so be sure not to tape this connection shut. A truck with a conventional 350 Chevy engine needs to idle 10 minutes for every 1000 gallons of tank capacity. Make sure the truck is tuned up and not running rich or having choke problems. You don't want to be putting unburned fuel and CO into the tank. CO can actually combust. A diesel engine would be better to use for this application if it is available.

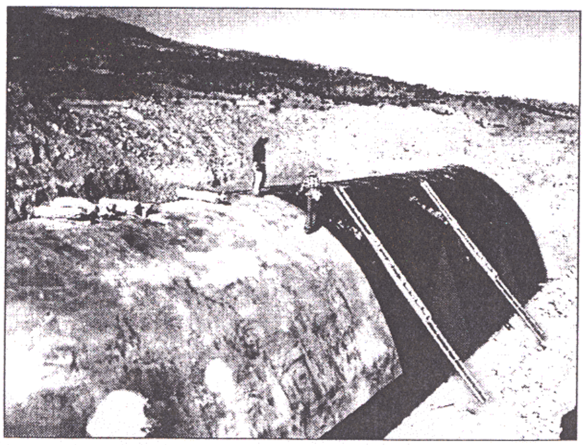
As an added precaution have someone duct tape the cut behind the cutting torch to prevent air from entering the tank during the actual process of cutting the hole. Any fuel you find in the bottom of the tank, once you've cut the hole, can be absorbed with sawdust, shoveled into empty feed sacks and properly disposed of.

NOTICE

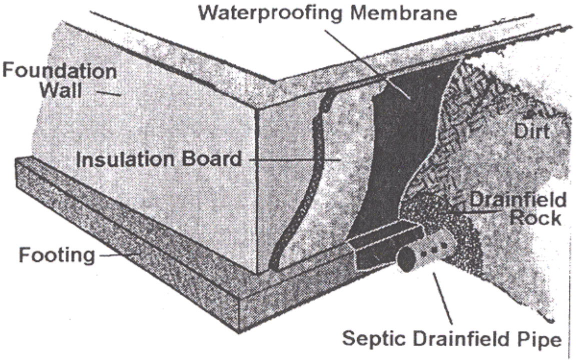
Unless you are knowledgeable and experienced in this area, you should purchase a tank which has already been cut open by a licensed fuel tank remover or purchase a new tank. This information is not intended to be encouragement or advice from the author in regards to cutting into a tank. If you decide to engage in such a dangerous and unpredictable activity, you will have to do it at your own risk!

Waterproofing

When constructing sub-earth homes and underground shelters which have shells comprised of porous materials, such as concrete or wood, make sure not to skimp on the waterproofing. There is nothing much worse than to backfill and landscape an underground shelter and then discover a leak. The only real solution is to call the backhoe or excavator back, uncover the shelter by removing the dirt, and re-do the waterproofing.



Putting on Paraseal Waterproofing



For waterproofing concrete shelters, a product called Para Seal is probably the best commercial product on the market today. Para Seal is a heavy mil P.V.C. material with a bentonite backing. It is a self-healing waterproofing system. If a hole is punctured through the P.V.C. and water seeps in, the bentonite swells up and stops the leak. Paraseal is made by Paramount Technical Products, 2600 Paramount Drive, P.O. Box 1042, Spearfish, SD 57783, (605) 642-4787 or (800) 658-5500. Another fairly good product is called ADF which is made by Tec Coatings, located in San Antonio, Texas.

For fuel tanks, the best material for waterproofing is epoxy coal tar. You can locate this coating material by contacting the nearest underground tank manufacturer or by ordering it through a commercial paint store.

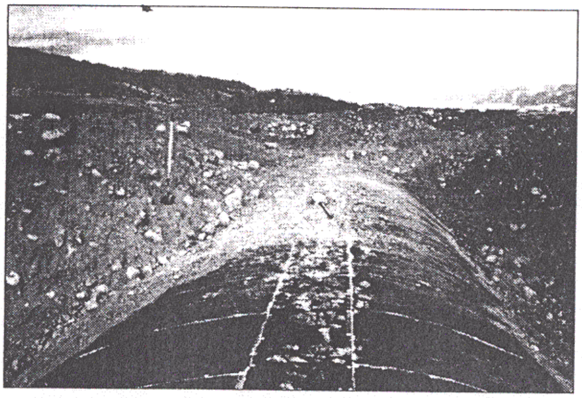
For culvert, a tar based foundation coat is adequate since the shell is galvanized material. Caution should be taken to make sure that the joints between sections and welded intersection joints are properly sealed to prevent leaking.

The steel quonset structures contain many bolt connections and tend to leak if not properly waterproofed. Polyurethane foam has been used successfully to waterproof this type of structure.

The newer generation of fiberglass shelters like the Subtec ES10 are considered to be watertight, but the old Theta modules have a tendency to leak.

Backfilling

Backfilling is the most critical construction phase of any structure system which relies on earth-arching for its structural strength. This includes fuel tanks, culvert, fiberglass pods, and steel quonset. The potential for serious problems with settling and deforming due to improper compaction should not be underestimated! Generally, the backfilling material should be screened in such a manner that nothing larger than a softball is placed within two feet of the surface of the tank or culvert. Larger rocks, due to the compaction pressure of the material above, tend to gradually migrate down onto the surface of the tank or culvert. This produces dents and point loads which can potentially compromise the structural integrity of the system.



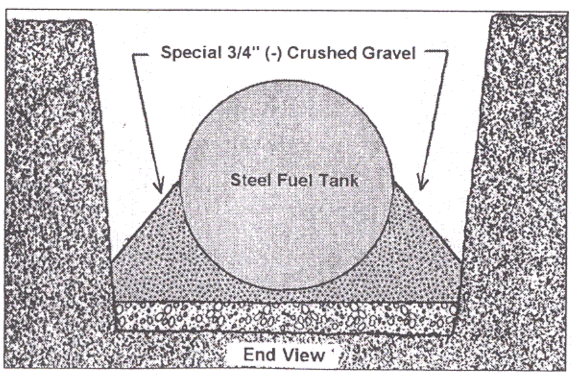
Backfilling the Shelter

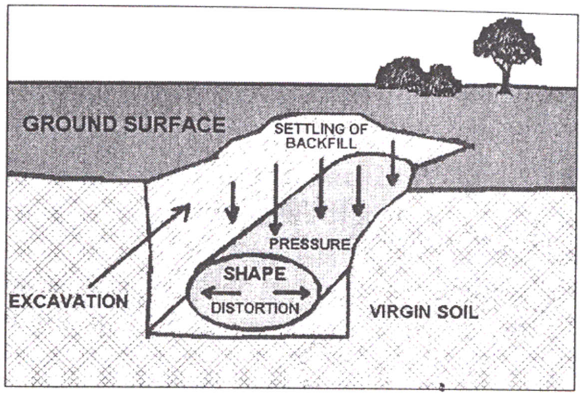
Earth-Arching

Earth-arching is a phenomena whereby the earth covering a "fully buried" structure, when subjected to an overpressure, acts as one integral unit, absorbs the pressure and as pressure penetrates down into the earth, the earth reduces and dissipates the pressure. The effect is that "fully buried" structures, without significant strength, only receive a fraction of the initial pressure which was applied to the surface of the ground, and survive without collapse. The term "fully buried" means the structure in question, be it a fiberglass dome, tank or culvert, is covered by at least a depth of earth which is equal to or greater than the diameter of the structure. In other words, earth-arching will not work if the shelter is not buried at a depth which provides an earth cover over the top of the shelter which is equal to or greater than the diameter or width of the tank, culvert or arch that it is covering.

Compaction

Another significant factor in relation to earth-arching effects is compaction. The earth-arching effect will not function to its capacity if the earth cover over the shelter is not uniformly compacted to a percentage of 95% Proctor. Compaction is not only important from the standpoint of achieving the





The Results of Poor Compaction

earth-arching effect to protect the shelter in the event of an overpressure, but it is also important in terms of keeping the tank or culvert from deforming and deflecting during the settling process.

A simple way to test for this 95% Proctor density is to jam your heel into compacted earth and if it barely leaves an imprint you have approximately 95% Proctor density.

Compaction can be thoroughly accomplished with a wacker tamper applied to each 8 to 12 inch layer of earth cover. The flat side of the bucket of a large excavator can be used as long as a repeated pounding action is applied.

The final aspect of achieving the earth-arching effect is the aggregate nature of the soil. Silty and clay soils will not, even when properly compacted, produce the earth-arching effect. The overall material must not contain any more than 15% silty fines or clay. On the other extreme, if the compacted backfill is comprised of significant amounts of material which is larger than 12 inches in diameter, the earth-arching effect will be compromised. Both coarse sand and gravel work well and facilitate earth-arching.

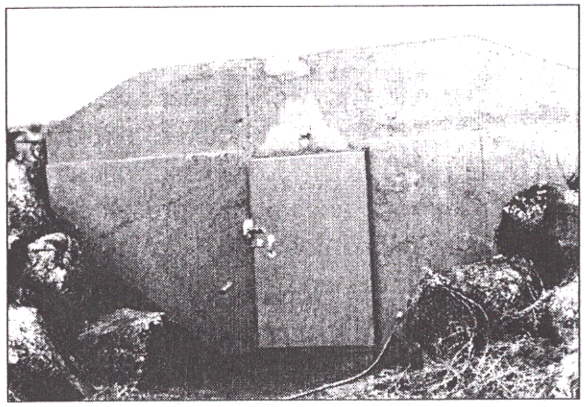
Landscaping Considerations

Efforts should be made to scrape off, stockpile and reserve any topsoil in the area on top of and around the shelter site. Be careful that this soil does not get used for backfilling, bedding pipes or other activities where earth with minimum rocks is needed. The topsoil may not seem all that valuable at the start of the project, but when the bulk of the project is done and it is time to landscape, the topsoil is extremely valuable. Not only should the soil be scraped off areas where excavations are going to occur, but also areas where subsoil from the excavation is going to be piled. The topsoil under these piles usually gets dug up and mixed in with the sub soil and thus wasted during the backfilling operations.

The landscape should also make consideration for security. Bushes, earth mounds, and large rocks should not be located on the grounds in such a way as to create concealment and cover for uninvited guests and intruders.

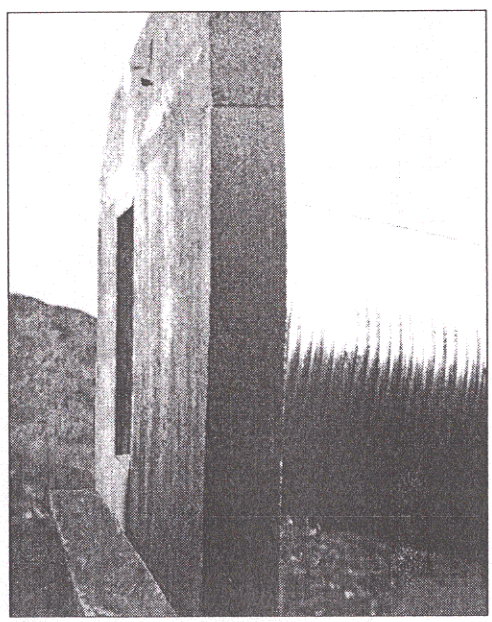
Doors

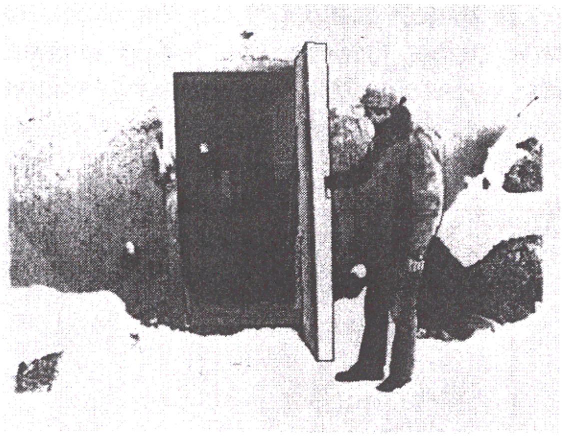
Shelter entry doors and hatches have three primary requirements: airtightness, security, and heat and overpressure resistance. An airtight seal is the primary requirement of any shelter door. This can be especially difficult to achieve with a homemade blast door. Doors built to resist heat, overpressure and thwart security threats are by their nature massive and difficult to get airtight seals on. One solution is to have a primary outer door which provides heat, overpressure and security protection and a secondary inner marine door which facilitates an excellent airtight seal.



Shelter Entrance Blast Door

Most shelters have doors which swing open to the outside (in contrast to doors that swing inward). The reason for this is that the door is easier to build that way. In the event of an overpressure, the outside pressure pushes the door onto the door frame and the door is supported by the frame on its entire periphery. The disadvantage is that rubble resulting from a blast can prevent the door from being opened, and if the shelter doesn't have an unblocked alternative entrance, the occupants must be freed by rescue teams coming from outside.





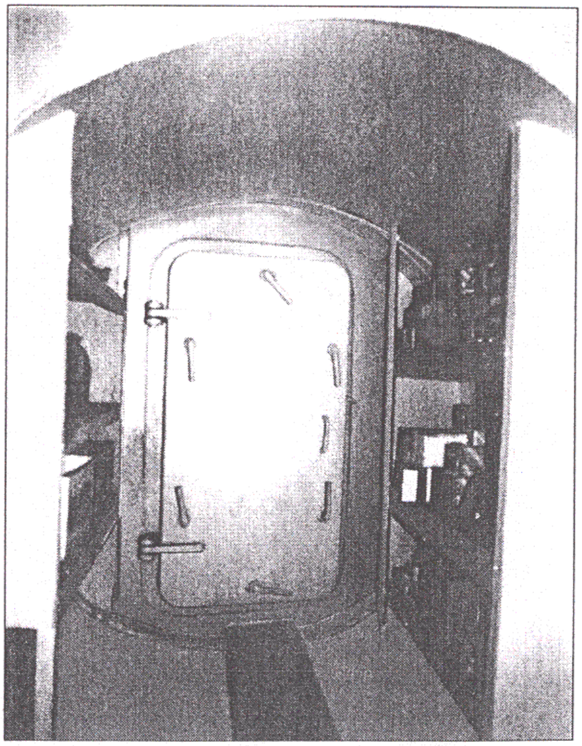
Doors opening to the inside allow occupants to open them even when blocked by accumulated rubble. These style doors are more difficult to construct because the overpressure is carried by dogs or pins which extend from the door into the door frame. These dogs transfer the overpressure to the door frame. Therefore, inwardly opening doors need to be small.

The best solution to being trapped inside a shelter by rubble is to have an alternative entrance/exit with a different profile, exposure and elevation. The idea here is that if one door is a horizontal surface walk-in type, then the other entrance/exit would be a vertical hatch coming up to the surface—ideally at a higher elevation. The problem of rubble blocking a vertical type hatch can be reduced by elevating the concrete reinforced hatch tube (see following pictures) several feet above the ground level, and have the hatch pivot horizontally to open, as opposed to flipping open vertically. One design which seems effective is the jack pivot type (as shown on the following page) which would allow occupants to lift the weight of any debris accumulated on top of the hatch.

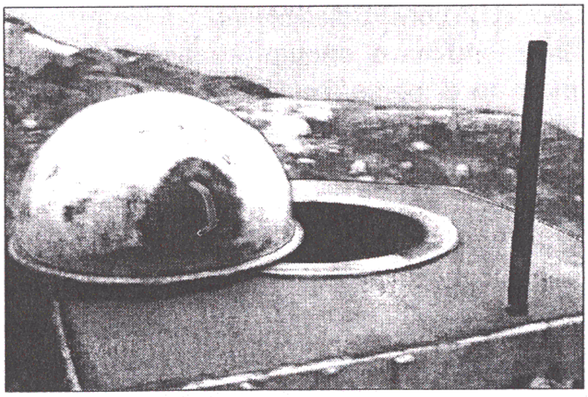
Door frames for exterior entry doors should be structurally substantial. In the case of a blast shelter, the door or hatch frame should be constructed of steel reinforced concrete and have enough surface area and mass to disperse the force of overpressure into the ground. This is important because if the overpressure is not transferred to the ground, it will be transferred directly to the entry tube which will be either crushed or driven into the shelter.

Doors should be outfitted on the inside with at least two chain binder arrangements which would tightly secure the door against the effects of negative overpressure and attempts by hostile individuals to make an unauthorized entry.

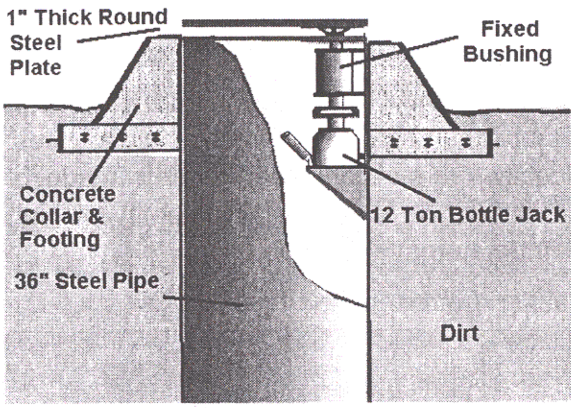
Another important aspect of doors are seals. Usually these are made of rubber. Rubber burns in case of intense surface fires. Ideally, fire-resistant fiber gaskets made of kevlar (which would retain integrity at high temperatures) should be used.



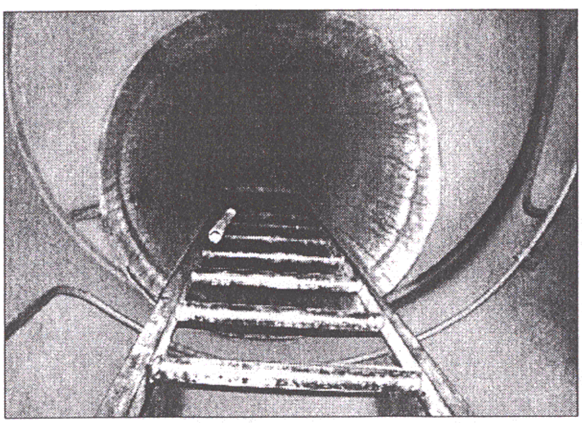
Marine Door



Pivoting Hatch Door
Vertical Entrance



Section of Vertical Entry Hatch



Vertical Entry / Exit
Looking Up From Inside Shelter

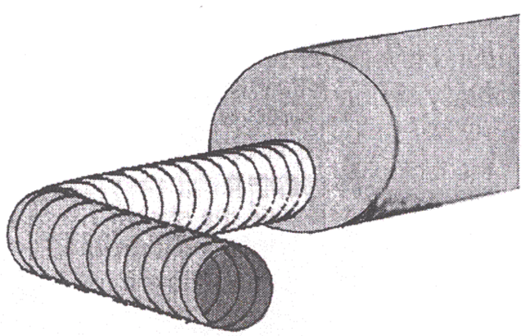
To protect the door from the effects of large caliber firearms and cutting torches, steel doors should be lined internally with at least 1 inch of steel reinforced concrete.

Entry Ways

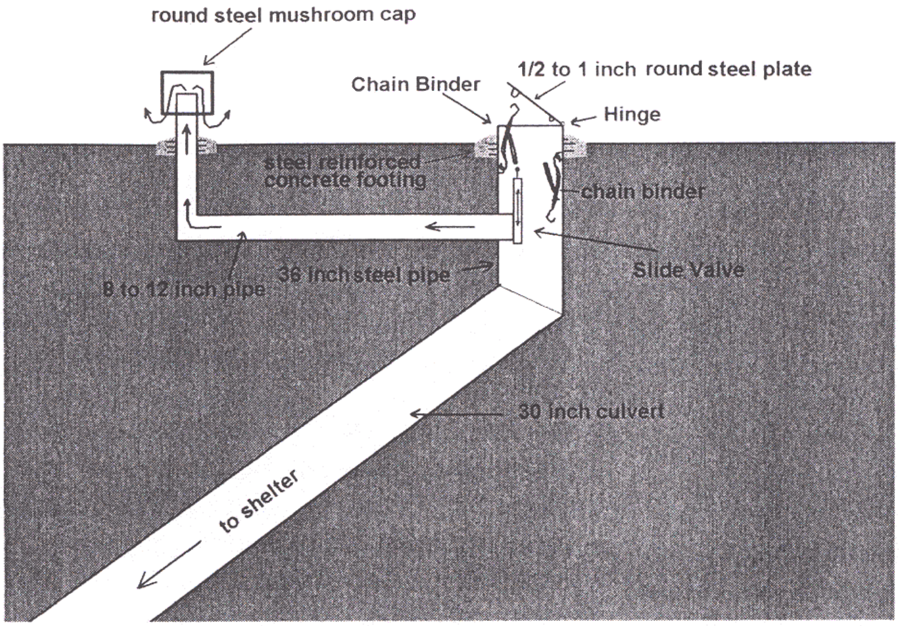
When designing shelter entry ways, the two factors which must be considered are attenuation of radiation and ease of access. The diameter, length and number of turns in an entry way will determine how much outside radiation comes into the shelter through the entrance way. Most shelter doors do not attenuate a significant amount of radiation. Shelter entrance way tunnels need to be configured so that they attenuate radiation, both gamma and neutron, and provide adequate access and escape.

Radiation attenuation is usually accomplished by extending the length of the entrance tunnel, incorporating turns in the entrance way tunnel, reducing the diameter of the entrance way tunnel, creating a barrier inside the tunnel, or any combination of these four.

Neutron radiation is only a problem in proximity to areas affected by the blast. Neutron radiation is not attenuated as easily



90 Degree Turn on Culvert Entry Way



as gamma radiation. Much more attenuation is needed to protect the occupants of a shelter from the initial deadly pulse of neutron radiation which will attempt to penetrate into the shelter through the entrance way in the areas affected by the blast.

You should never be able to open the door to a shelter and see directly into the shelter. If you can see into it, radiation can penetrate into it. One good test which will indicate how well the entrance way will reduce radiation is to open the hatch-ways and doors to your shelter and go inside to where the entrance way actually meets the shelter. Make sure no lights are on inside the shelter. Turn around and look back out the entrance way toward the outside. Observe how much sunlight, if any, is being reflected down the tunnel way from the outside.

The presence or absence of outside light being reflected down into the interior of the shelter via the entrance way tunnel is a good general indication of how adequately the tunnel will shield the occupants from the penetration of neutron radiation. Neutron radiation is much like light in its reflecting capabilities.

Neutron radiation has a scattering effect which enables it to effectively penetrate around corners. A 90 degree turn in a entrance way tunnel will only reduce the penetration of neutron radiation by 20%. In effect, 80% of the neutron radiation will get around the 90 degree turn in the entrance tunnel. A second 90 degree turn in the entry way tunnel will reduce the 80% that got around the first turn in the tunnel by a factor of 20%. In essence, if you had 9,000 rems of neutron radiation pulsing into the shelter entry way, the first 90 degree turn would reduce the neutron radiation to 7,200 rems and the second 90 degree turn in the tunnel would reduce this 7,200 rems to 5,760 rems. It is going to take many 90 degree turns and/or the addition of tunnel length and barriers to reduce the neutron radiation to a survivable level.

Barrier shielding is a practical solution to the penetration of neutron radiation. Substances with high hydrogen contents provide the best shielding and attenuation of neutron radiation. Stacking full water containers in the entrance way is one solution. Sandbags full of sawdust is another. The ideal neutron shielding barrier would be a massive, hinged interior door which contained an interior water bladder. Water is an excellent substance for shielding neutron radiation.

Gamma radiation is a product of airborne fallout dust particles and its presence will extend far beyond the area affected by blast. However, gamma radiation does not have the same scattering effects as neutron radiation. Generally speaking, one 90 degree turn in an entrance way will attenuate 90% of any gamma radiation coming in through the entrance way. If you had an entrance way with two 90 degree turns in it, the first turn would attenuate 90% of any gamma radiation coming through the entrance way allowing no more than 10% to pass the first 90 degree turn and the second 90 degree turn would reduce this 10% of the original gamma radiation by 90% allowing only 1% of the original radiation through the entrance way into the shelter. See the following chapter on Radiation Shielding for more detailed information on attenuating radiation in entry ways.

This does not take into account any attenuation of gamma radiation as a result of the length of the entrance way, its diameter or any shielding which the doors may provide.

You can start to see how much trouble and expense can be avoided by locating oneself and one's shelter away from known target areas which could experience the effects of blast.

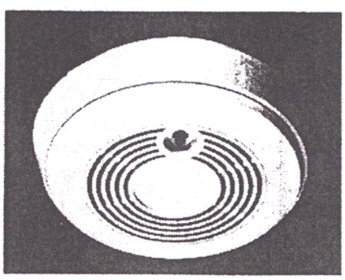
Walk-in type entrances have certain advantages and disadvantages. They can be a blessing when it comes to getting people and equipment in and out of the shelter quickly. If you have elderly people in your shelter group, a walk-in entry may well be a necessity. Having a crawl-in or climb-down type entrance way can make movement of people and equipment in and out of the shelter slow or in the case of larger equipment, impossible. Walk-in entry ways can provide the needed space for decontamination facilities and extra storage.

The disadvantage to a walk-in entry is that its nature involves utilizing a larger diameter pipe or culvert. This larger diameter dictates the need for more 90 degree turns and more tunnel length to effectively attenuate the increased radiation coming into the shelter through the larger entry way opening.

It is important to have more than one entrance way in the event that one becomes blocked by debris or compromised due to a security problem. In consideration of the latter situation, it would be good to make the alternate entrance-exit hidden on the surface, if possible.

Fire Suppression

The threat of fire should not be taken lightly. A fire in a confined area can lead to a rapid build-up of heat, hot gasses and smoke. The last thing you want is to have a fire that drives you out of a shelter at a time when outside conditions have driven you into the shelter. **Install smoke detectors**, have an ABC fire extinguisher, and if you have running water, have garden hoses in the shelter. Surviving a shelter fire will mean quick detection and quick suppression. Also, make sure flammable liquids are kept isolated in metal



cabinets or behind airtight bulkheads away from living areas.

Sewage Disposal and Sanitation

Toilets and sewage disposal are an obvious necessity. If you have a smaller shelter it may mean a chemical toilet and some sort of holding tank. In a larger shelter where you have running water, flush toilets are the way to go. This poses a problem with the disposal of the resulting sewage. The ideal is to have your shelter situated in the slope of a hill, enabling you to utilize gravity flow for removing waste water to a drain field. If you are looking for blast protection, you should consider that conventional septic tanks have little or no resistance to overpressure. This can be solved by building or purchasing a special blastproof tank or placing the septic tank under some portion of the shelter or its entryway where it will enjoy existing blast protection.

If you are not located in some sort of slope and cannot use gravity flow, a holding tank and pumping station must be used. This equipment is commercially available off the shelves at plumbing supply stores.

A popular subject when shopping for shelter space or designing shelters is per capita of persons per toilets. Ideally the shelter would have no more than 20 persons per toilet.

Being able to shower is an extremely important issue. Sanitation and cleanliness are not only important to prevent the spread of sickness and disease, but also have psychological benefits. Showers, unlike toilets, can be scheduled. One shower for every 25 persons should be adequate.

Government Regulations

All states have requirements for permits when electrical work is being done. Following electrical codes will greatly enhance the safety and performance of the shelter wiring.

Most counties have regulations regarding septic systems. If the shelter is a single purpose shelter you may be able to get an exemption as long as the sewer system is not being used.

Regulations in regard to plumbing permits vary from state to state and county to county.

Building permits are required in most areas. The only salvation for the shelter builder in this regard is that there is an appendix in the back of the U.B.C. codebook for Fallout Shelters. It is as liberal as can be and is the one thing you should politely bring to the attention of the building, plumbing, and electrical inspectors, the county sanitarian and state fire marshal, if they happen to come around.

Unfortunately, there are enough laws that if you get on the wrong side of the government, they can make your life miserable with arbitrary enforcement.

Most people who build shelters want confidentiality, and for good reasons. Unfortunately the government makes this very difficult.

The following is a reprint of the U.B.C. Appendix on Fallout Shelters.

1991 UNIFORM BUILDING CODE

APPENDIX

Chapter 57 (Pages 991 & 992)

REGULATIONS GOVERNING FALLOUT SHELTERS

Purpose

Sec. 5701. The purpose of this appendix is to establish minimum criteria which must be met before a building or building space can be constructed, occupied, used or designated a fallout shelter.

Scope

Sec. 5702. The scope of this appendix extends to building spaces designated for use as fallout shelters, including periods of drill and instruction for this purpose.

Definitions

Sec. 5703. FALLOUT SHELTER is any room, structure or space designated as such and providing its occupants with protection at a minimum protection factor of 40 from gamma radiation from fallout from a nuclear explosion as determined by a qualified fallout shelter analyst certified by the Office of Civil Defense. Area used for storage of shelter supplies need not have a protection factor of 40.

DUAL-USE FALLOUT SHELTER is a fallout shelter having a normal, routine use and occupancy as well as an emergency use as a fallout shelter.

SINGLE-PURPOSE FALLOUT SHELTER is a fallout shelter having no use or occupancy except as a fallout shelter.

PROTECTION FACTOR is a factor used to express the relation between the amount of fallout gamma radiation that would be received by an unprotected person and the amount that would be received by one in a shelter.

UNIT OF EGRESS WIDTH is 22 inches.

Occupancy Requirements

Sec. 5704. (a) **General.** Nothing in these regulations shall be construed as preventing the dual use or multiple use of normal occupancy space as fallout shelter space, providing the minimum requirements for each use are met.

(b) **Mixed Occupancy.** The occupancy classification shall be determined by the normal use of the building. When a normal-use space is designed to have an emergency use as a fallout shelter in addition to the normal use, the most restrictive requirements for all such uses shall be met.

(c) **Occupancy Separation.** No occupancy separation is required between that portion designated as a fallout shelter and the remainder of the building.

(d) **Space and Ventilation.** A minimum of 10 square feet of net floor area shall be provided per shelter occupant. Partitions, columns and area for storage of federal shelter supplies also may be included in net area. A minimum of 65 cubic feet of volume shall be provided per shelter occupant. A minimum of 3 cubic feet of fresh air per minute per person shall be provided.

In addition, the shelter shall have a ventilating rate sufficient to maintain a daily average effective temperature of not more than 820F. for at least 90 percent of the days of the year.

(e) **Illumination.** No special lighting levels are required.

(f) **Hazards.** Hazardous utility lines such as steam, gas and oil shall not be located in or near the shelter unless provision is made to control such lines by valving or other approved means.

Exits

Sec. 5705. There shall be no fewer than two widely spaced exits from a fallout shelter, leading directly to other spaces of the building or outdoors. Exits from the fallout shelter shall aggregate at least one unit of egress width for every 200 shelter occupants. In no case shall a single exit be less than 24 inches wide.

Flame-spread Index of Interior Surfaces

Sec. 5706. Interior surfaces of single purpose fallout shelters shall have a flamespread index not exceeding 200.

Minimum Design Loads

Sec. 5707. (a) **Dual-use Fallout Shelters.** In the case of dual-use fallout shelters, design live load required for the normal use shall govern, except that concentrated loads shall be considered.

(b) **Single-purpose Fallout Shelters.** Minimum live loads for floor design in single purpose fallout shelters shall be 40 pounds per square foot except that concentrated loads shall be considered.

Sanitation

Sec. 5708. Toilets, either flush-type operating from the normal water supply system, or chemical or other types, shall be provided on the basis of one toilet per 50 fallout shelter occupants. Fifty percent of the toilets may be provided outside the fallout shelter area. Empty water containers may be considered as fulfilling this requirement.