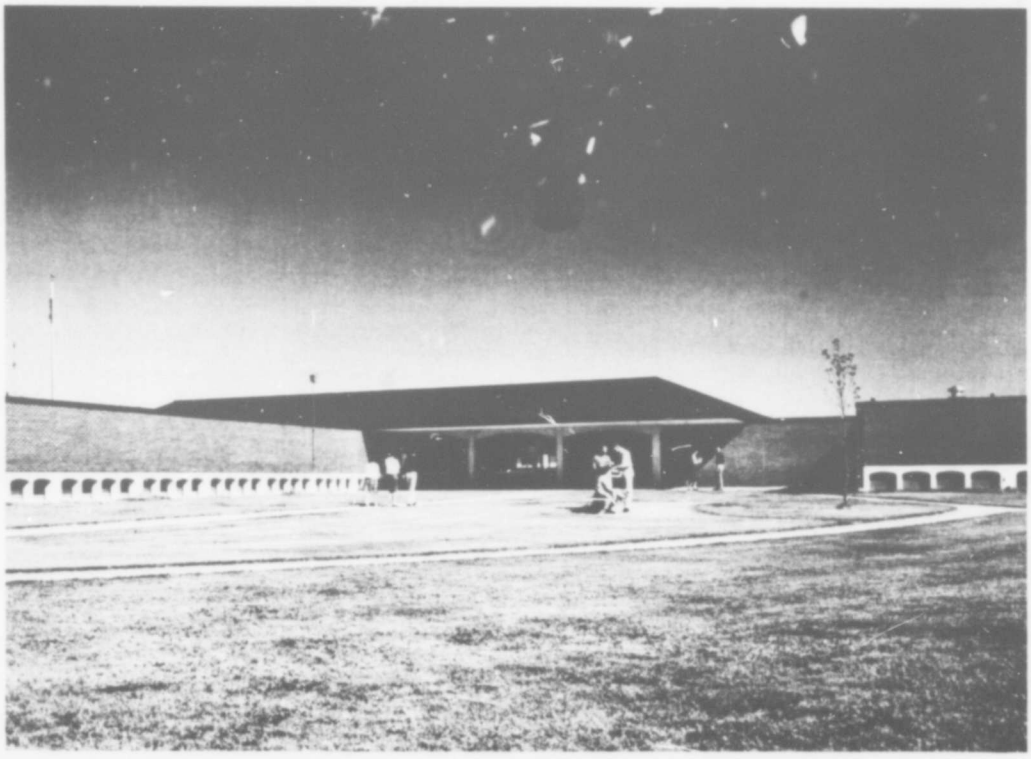
AD 664439

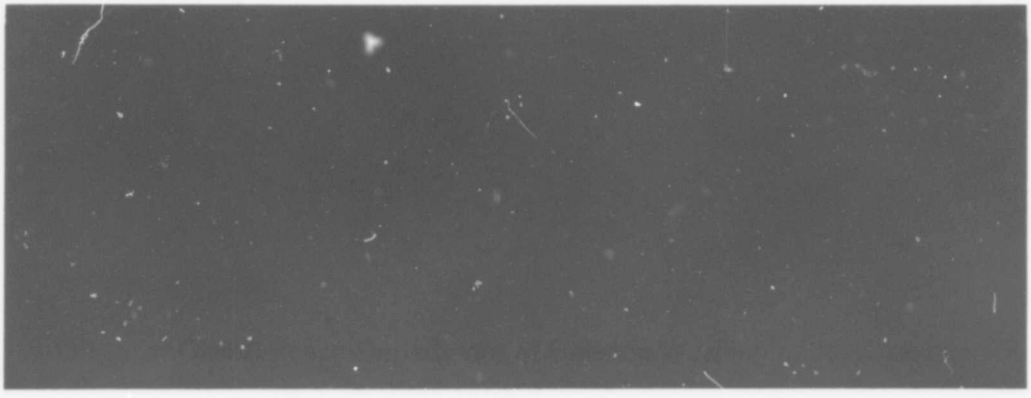


TR-39 DECEMBER 1967
(supersedes TR-39 December 1966)

# Fallout Shelters



Blackwell Senior High School, Blackwell, Oklahoma • Caudill, Rowlett, Scott, Architects and Planners, Houston, Texas
406 shelter spaces. First Honor Award in 1966 Awards Program—Buildings with Fallout Shelter.



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CODES & STANDARDS
Fallout Shelters

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# the Fallout Shelter Program

## to the reader:

The purpose of this section of Sweets Catalog is to provide technical information and references for the convenience of design professionals. This information is supplemented by publications and by the architectural and engineering services described below.

The architectural and engineering support for the National Fallout Shelter Program comes from the continued cooperation of the officers, members and staff of such dedicated groups as the American Institute of Architects, the American Institute of Planners, the Consulting Engineers Council, the American Society of Civil Engineers, the Associated General Contractors of America, Inc., the Engineers Joint Council, the National Society for Professional Engineers, and the Nation's outstanding colleges and graduate schools of architecture and engineering. These organizations are a constant source of advice to us on improved shielding technology.

This support by the professional societies plus the individual contributions of many talented architects and engineers is responsible for a growing competence in fallout shelter design and the incorporation of dual-use shelter in many new construction projects at little or no additional cost to building owners.

*—Office of Civil Defense*

## messages from the President and the Secretary of Defense

President Johnson has said, *"It is clear that, without fallout protection for our citizens, all defense weapons lose much of their effectiveness in saving lives. This also appears to be the least expensive way of saving lives and the one which has clear value even without other systems."*

Secretary McNamara related civil defense to the defense posture of the Nation when he said, *"Three major programs constitute our general nuclear war forces: (1) the strategic offensive forces, (2) the continental air and missile defense forces, and (3) civil defense. Analysis clearly demonstrates the distinct utility of a nationwide fallout shelter program in reducing fatalities at all levels of attack."*

## what is fallout?

The term "fallout" refers to dust and debris carrying the radioactive particles resulting from a nuclear detonation. This dust and debris is carried to the upper air from the bomb crater of a ground burst, it is then carried by the upper air currents and deposited over an enormous geographic area, well beyond the areas subject to blast and thermal effects. When deposited, it accumulates on horizontal surfaces such as the roofs of buildings or the ground. Fallout shelters are designed to protect occupants from the lethal effects of the gamma radiation originating from the radioactive material accumulated on these "source planes."

## the national civil defense objective

A principal objective of the Nation's civil defense program is the establishment of a National Shelter System providing effective protection against fallout radiation for every man, woman and child whenever and wherever needed.

## how can this objective be achieved?

A significant shelter resource has already been identified and marked in existing buildings. However, much of this shelter is located in the heart of urban centers where the cumulative weight of the construction materials in conventional construction provide "barrier shielding." Thus a surplus of shelter exists in the central area of many large cities while protection is available to only a portion of the family (at home) population in residential areas and in the smaller communities. The shelter deficit in these areas can be eliminated most economically by the incorporation of effective dual-use shelter space in new public and private buildings. Many new projects throughout the country provide ample demonstration that such shelter can be achieved economically without adverse effect on either functional or aesthetic quality. The architects, engineers and planners responsible for the creation of new construction are urged to give special and serious consideration to the inclusion of dual-use shelter space as an additional asset in each new design.

## the OCD program for professional development

Graduate level courses in Fallout Shelter Analysis are continually offered at convenient locations. To date more than 14,000 architects and engineers have officially qualified as "Fallout Shelter Analyst" through successful completion of the basic course. An architect or consulting engineer wishing to enroll in either the basic course or a refresher course should contact the Regional Director of the OCD region in which he is located. See page 8 for a list of regions.

## Architectural and Engineering Advisory Service

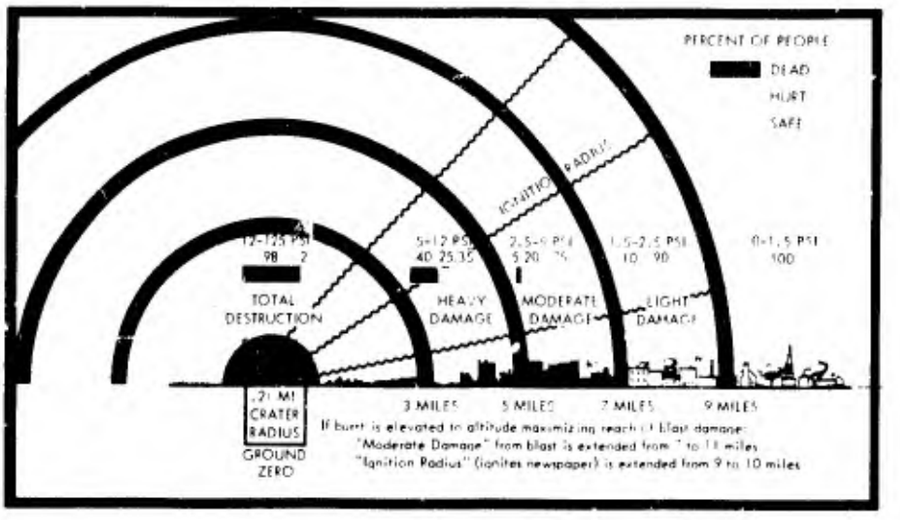
Architectural and engineering firms as well as building owners not having a capability in fallout shelter analysis may request advisory service through local or State civil defense offices. A qualified instructor in fallout shelter analysis, or a qualified analyst, will be designated by OCD to meet with the architect's staff to explain how protection can be achieved through current shelter technology.

## Construction Industry Civil Defense Advisory Committee

In the establishment of these and other elements of the Nation's civil defense program, OCD has had the benefit of the advice of leading design professionals. Formed at the suggestion of Philip Will, Jr., FAIA, national president of the AIA in 1962, this Committee has advised the Director of Civil Defense on all matters affecting design and construction. Its membership comprises the Executive Director and elected national officers of AIA, AIP, CEC, NSPE, ASCE, EJC and the AGC. The Advisory Committee has followed the progress of the program for development of dual-use low-cost fallout shelter in buildings and has found the program both economically and technically sound.

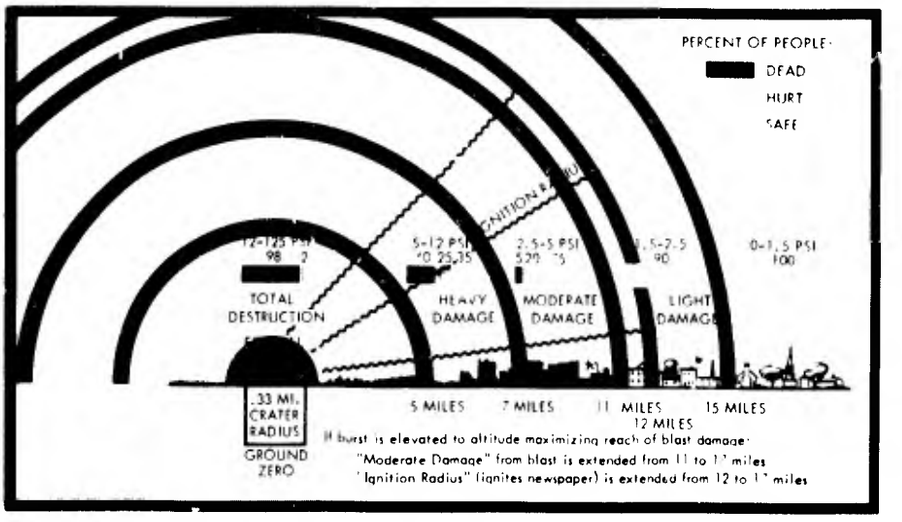
## effects of a 5-MT blast

People close to the detonation, within 3 miles of ground zero, are not likely to survive the blast and thermal effects. Out from the total destruction ring, chances for survival improve markedly. The percentage of the population surviving blast and thermal effects increases rapidly as the distance from ground zero increases, but a large portion of the survivors would be exposed to the lethal effects of radioactive fallout.




## effects of a 20-MT blast

While this amounts to a fourfold increase in megatonnage over the five-megaton weapon the same blast and thermal effects occur at less than twice the distance from ground zero. As in the case of the five-megaton weapon, millions of people could survive these initial effects.

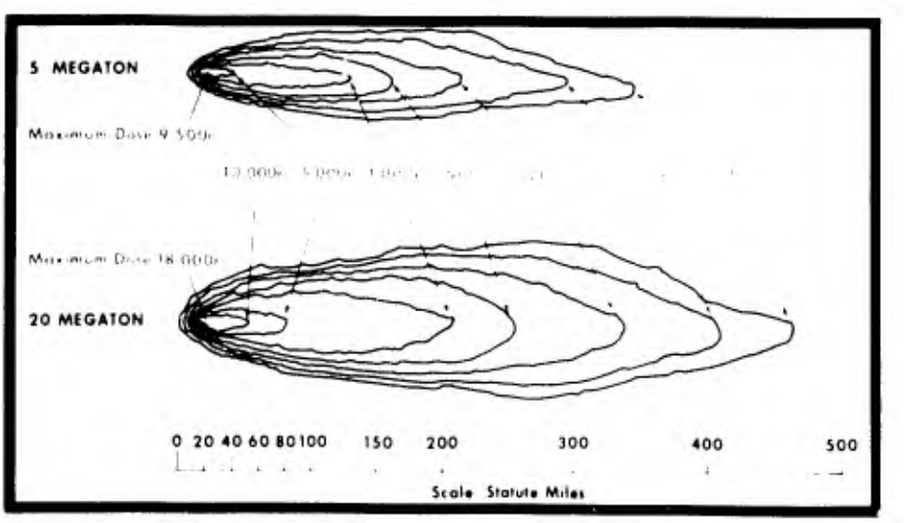



## unshielded maximum equivalent radiation dose contours

Geographical coverage of radioactive fallout from 5 to 20 megaton surface blasts would be extensive. Based on a 25 mph upper air wind, significant amounts of fallout from these weapons would be deposited over thousands of square miles of area downwind.

A dose of over 200 roentgens could cause disabling illness and some deaths. At 450 roentgens there is a 50-50 probability of death, and over 600 roentgens would leave few survivors.

In an actual attack, fallout from several weapons could overlap increasing radiation levels further.



# no area of the United States is safe from fallout

Assuming a random attack against a wide range of military, industrial and population targets, fallout will be distributed over very large areas of the country. The actual area affected will depend on the season, wind conditions and other variables, but no area can be designated as safe.

The maps show the geographic distribution of various levels of radioactivity resulting from an assumed attack. Targeting variables included such matters as how war starts, enemy abort rates from malfunctions, attrition of incoming weapons from U.S. military action, duration of attack, weapons accuracy, and upper wind direction and velocity.

About 75% of the land would be covered with dangerous levels of radioactive fallout if average winds prevailed. Areas could virtually all be covered under different wind conditions.

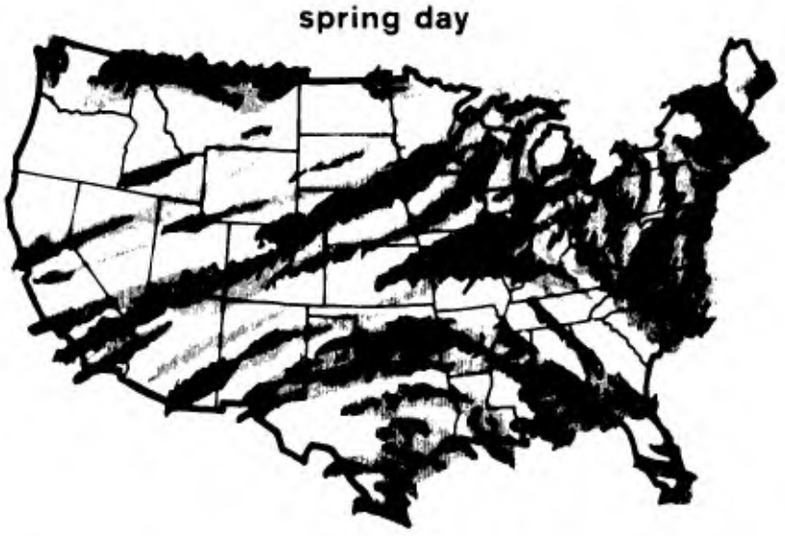
The darkest areas would require a week or two weeks stay in shelters. Less dark areas would require two days to one week. The light areas would require shelter only for the first day or two.

Much of the area which was free of fallout with the spring day winds is covered with serious amounts of fallout under the fall day conditions.

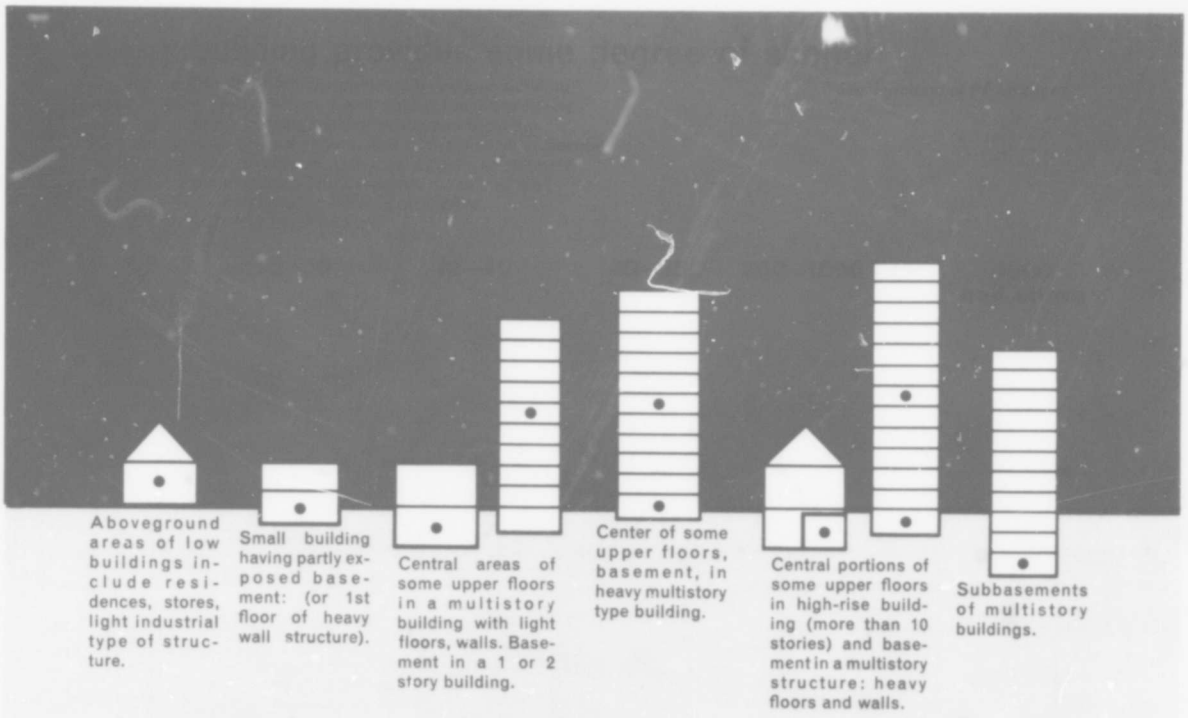
Even if targets, enemy intentions and offensive capabilities could be accurately predicted, the winds as of any day on which a potential attack might occur, could not be so predicted. *Therefore we must plan on providing fallout protection everywhere.*

- No shelter required under this wind condition
- Up to 2 days shelter occupancy
- 2 days to 1 week shelter occupancy
- 1 week to 2 weeks shelter occupancy followed by decontamination in exceptional areas

**spring day**



**fall day**



Aboveground areas of low buildings include residences, stores, light industrial type of structure.

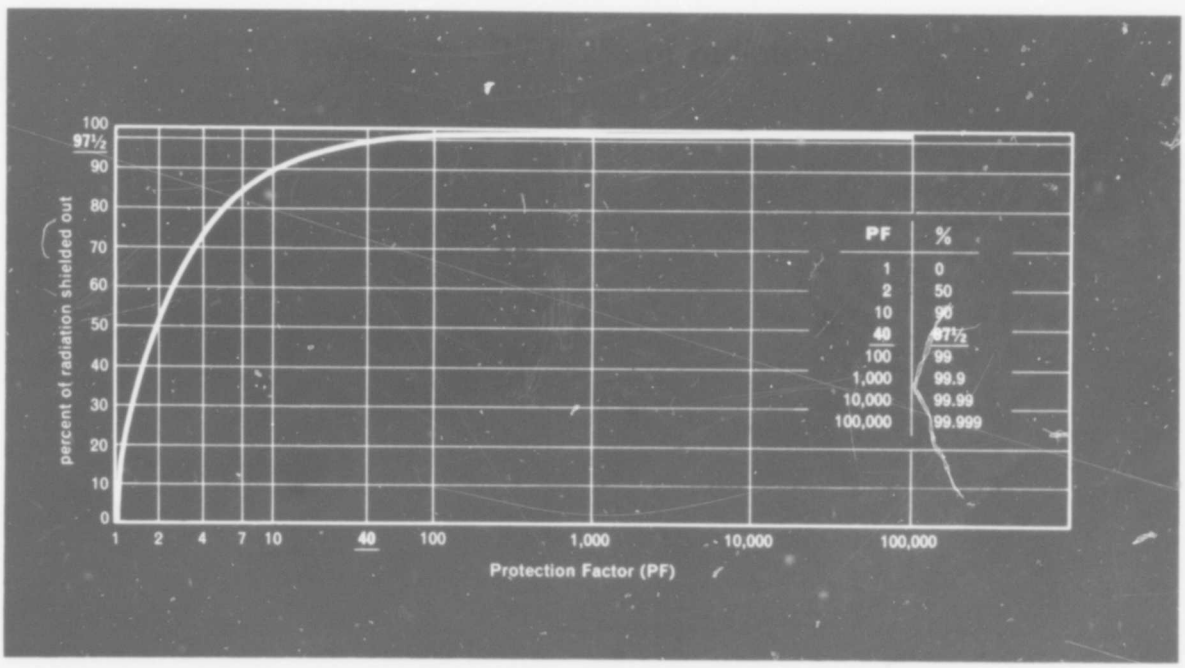
Small building having partly exposed basement: (or 1st floor of heavy wall structure).

Central areas of some upper floors in a multistory building with light floors, walls. Basement in a 1 or 2 story building.

Center of some upper floors, basement, in heavy multistory type building.

Central portions of some upper floors in high-rise building (more than 10 stories) and basement in a multistory structure: heavy floors and walls.

Subbasements of multistory buildings.



# basic terminology of radiation shielding

Some of the terms used in referring to protective control from fallout gamma radiation are defined briefly as follows:

Protection Factor (PF) expresses the relation between the amount of gamma radiation that would be received by an unprotected person compared to the amount that would be received by one in a shelter. For example, an occupant of a shelter with a PF of 40 would be exposed to a dose rate 1/40 (or 2½% of the rate to which he would be exposed if his location were unprotected.

Gamma radiation reaches an individual in an enclosure from several sources: The *roof contribution* refers to radiation originating from radioactive particles (dust and debris) which may accumulate on an overhead source plane; the *ground contribution* refers to all similar radiation from fallout originating from the ground source plane. The ground contribution is further subdivided into ground direct, wall scatter, skyshine and ceiling shine.

## basic concepts of radiation shielding

Shelters with high protection factors are achieved by the planning and control of geometric and barrier relationships between the radioactive source and sheltered enclosure. *Geometric shielding* places people out of the direct path of radiation or at some distance from it. *Barrier shielding* places mass between the shelter occupant and the radioactive source.

The sections on this page illustrate radiation types and sources and some of the application of shielding techniques.

Other examples of shielding techniques include reducing window area (particularly raising the sill height), partially depressing a building into the ground, or grading slope away from the building to create an earth barrier, arranging retaining walls and planter boxes as barriers, utilizing screen walls at entrances to provide barrier baffles, arranging building elements to protect a core area and filling hollow masonry cavities with sand or gravel to increase the mass barrier.

## technical requirements for fallout shelter

Detailed Department of Defense studies of the life saving potential of fallout shelters indicate that for the current time-frame and for the foreseeable future, shelters with a protection factor of 40 could save over 90% of those persons who would otherwise die if unprotected against potential lethal radiation levels. Therefore, design and construction objectives are:

**A. Shelters for the General Population.** *In modifications to existing buildings and in new construction, protection factors and shelter areas should be maximized to the extent possible, at nominal or no cost, using slanting techniques.* Although minimum protection for a shelter area should be at least PF 40, the objective is to obtain the best protection factor possible. Computations indicate that decreasing returns in added lives saved per added dollar invested are obtained as PF's are increased significantly above 40. On a nationwide basis, therefore, it would provide better life-saving potential per dollar, for the same dollar expenditure, to obtain more shelter space of lower PF than only a few shelter spaces with very high PF.

**B. Shelters for Emergency Operational Personnel.** As it is anticipated that personnel with emergency functions may have to expose themselves to dangerous radiation levels during the performance of their duties, it is desirable to obtain the best possible protection factors for emergency operating centers or shelters housing emergency operational personnel, with an acceptable minimum objective of at least 100 PF.

**C. Objective is to Increase Protection Factors.** Recognizing that in many design and construction projects it may be physically difficult or expensive to attain these minimum shielding objectives, it is still a worthwhile objective to increase protection factors to any level. Under many potential levels of radiation exposure, even these lower protection factors will save lives or minimize illness.

## space and ventilation requirements

A. Ten square feet of shelter floor area per person shall be provided.

B. At least 65 cubic feet of space per person shall be provided.

C. If the shelter capacity is based on minimum space requirements, then at least 3 cubic feet of fresh air per minute per person are required.

D. Shelter capacity or occupancy time may be limited by the volume of the room and not by its area. This is particularly true if mechanical ventilation is inadequate. When ventilation is limited, the following table can be used for determining the relation of space requirements to ventilation:

| time for one complete air change (minutes)** | volume of space required per person (cu. ft.) |
|---|---|
| 1,000 or more | 500 |
| 600 | 450 |
| 400 | 400 |
| 200 | 300 |
| 100 | 200 |
| 60 | 150 |
| 35 | 100 |
| 22 | 65 |

**computed as a ratio: $\frac{\text{net volume of space (cu. ft.)}}{\text{fresh air supply (cfm)}}$

E. No filters are required on mechanical ventilation systems other than those necessary for the normal daily use of the space.

F. In general, incremental costs of fixed ventilation equipment to meet shelter requirements shall not exceed $2.50 per shelter space, the estimated cost of ventilating the shelter with packaged ventilation equipment approved by the Office of Civil Defense.

**NOTE. In geographic areas where temperature or humidity are excessive, the minimum ventilation criteria included above may require augmentation to improve habitability. Professional judgment should be exercised by the architect or engineer to optimize habitability within budget limitations.*

## construction requirements

A. In general, conventional methods of design and construction for concrete, wood, steel, brick, structural tile and other products will be followed. Allowable stresses and/or load factors as defined in the applicable codes shall be used.

B. The structure shall be designed for a useful life of at least 10 years.

C. At least one unit of access and egress width should be provided for every 200 shelter occupants (a unit width is 22 inches, the space required for free travel of one aisle of persons). In no case shall a single passage width be less than 24 inches; nor shall there be less than two widely separated means of egress from each building. Emergency-type hatchways may be used as a means of egress. They shall be designed so that any normal-size adult can readily enter or leave the main shelter chamber.

D. In areas subject to high-ground water conditions, provisions shall be made to prevent flotation of underground shelters.

E. Provisions shall be made to insure the shelter interior will remain reasonably dry.

F. To the extent practicable, hazardous utility lines such as steam, gas, etc., should not be located in or near the shelter area unless provision is made to control such hazards before the shelter is occupied.

G. All shelters shall be constructed to minimize the danger of fire from both external and internal sources.

## services

A. Provisions shall be made for the storage of basic shelter supplies by alloting 1½ cubic feet per person. This volume may be reduced to 0.6 cubic feet per person if the standard OCD 17½ gallon water drums are not utilized. The live load attributable to placing these supplies should be considered. Fallout shelters with a capacity of 50 or more persons, which have been made available to the public, should be stocked with:

1. Water—to provide each person with a minimum of 3½ gallons of water.
2. Food—special crackers, biscuits, or wafers, etc., to provide 10,000 calories per person, deducting comparable food already available in the building.
3. Medical care kits.
4. Sanitation kits which include toilet tissue, sanitary napkins, toilet seat and commode chemicals. Empty water containers convert to commodes.
5. Radiation detection instruments.

B. *Water Supply.* An adequate supply of water from a suitable well, water trapped in the piping of the facility, or water storage tanks should be substituted, wherever feasible, for storage of drinking water in the standard OCD 17½ gallon water drums.

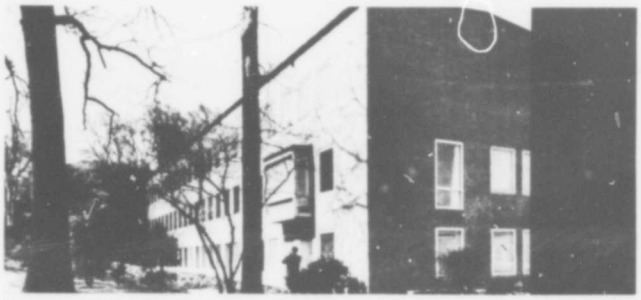
C. *Sanitation.* Toilets may be provided on the basis of one per 50 occupants. In lieu of A. 4 above, other austere provisions, based on economical considerations may be made for the disposal of garbage, trash, and human waste. Fifty percent of the toilets may be outside the shelter area, in other parts of the building, provided they are readily accessible without hazardous exposure to fallout gamma radiation.

D *Electrical power.* It is assumed that normal electrical power will be available, therefore emergency generators are not required. No special lighting levels are required in fallout shelters. The following levels are deemed adequate for emergency occupancies:

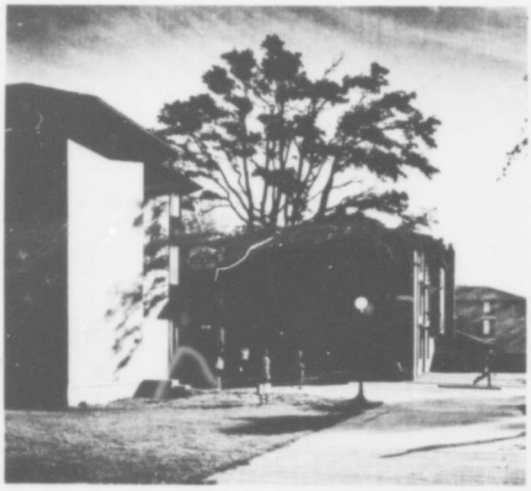
1. Sleeping areas—2-foot candles at floor level.
2. Activity areas—5-foot candles at floor level.
3. Administrative and medical areas—20-foot candles at desk level.

*Taken from OCD Publication TM 61-3, TECHNICAL REQUIREMENTS FOR FALLOUT SHELTERS, March, 1965.*

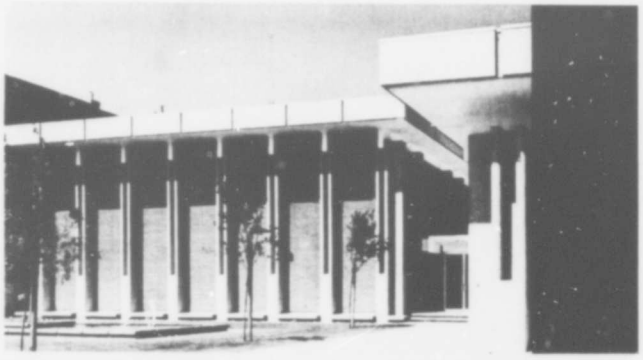
## buildings with shelter



Chancery of the Royal Netherlands Embassy, Washington, D.C., by Ir. P. H. Tauber, B.I., B.N.A., Alkmaar, Holland and Deigert and Yerkes and Associates, Architects, Washington, D.C., received First Honor Award in 1966 Awards Program conducted by AIA for OCD. It contains 320 shelter spaces.



Dormitory Group, Central Washington State College, Ellensberg, Washington by Fred Bassetti & Company, Architects, Seattle, received First Honor Award in 1966 Awards Program conducted by AIA for OCD. It contains 520 shelter spaces.



Watsonville City Hall, Watsonville, California, Robert B. Wong AIA, Donald Sandy, Jr., William W. Hedley, AIA, Associated Architects, San Francisco, received Award of Merit in 1966 Awards Program conducted by AIA for OCD. It contains 930 shelter spaces.

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## OCD regional offices

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OCD region four
Federal Center
Battle Creek, Michigan 49016

OCD region five
Federal Center
Denton, Texas 76202

OCD region six
Denver Federal Center, Building 50
Denver, Colorado 80225

OCD region seven
Federal Center
Santa Rosa, California 95402

OCD region eight
Everett, Washington 98201

## OCD publications available to architects, engineers and building owners

A partial list of publications available by writing to the A. G. Publications Center, Civil Defense Branch, 2800 Eastern Blvd., (Middle River), Baltimore, Md. 21220, follows:

| | |
|---|---|
| MP-20 | Publications Index |
| TR-19 | National School Fallout Shelter Design Competition Awards |
| TR-21 | Industrial Architecture—Fallout Shelters |
| TR-27 | New Buildings with Fallout Protection |
| TR-32 | City Halls with Emergency Operating Centers |
| TR-33 | Schools Built with Fallout Shelter |
| TR-37 | Buildings with Fallout Shelter |
| TR-41 | Fallout Protected Schools |
| TR-46 | Community Development and Civil Defense |
| TM-61-3 | Technical Requirements for Fallout Shelters |
| L-38 | Shelter Development—Architect and Engineer Activities |
| L-41 | Nuclear Defense Design for Architects and Engineers |