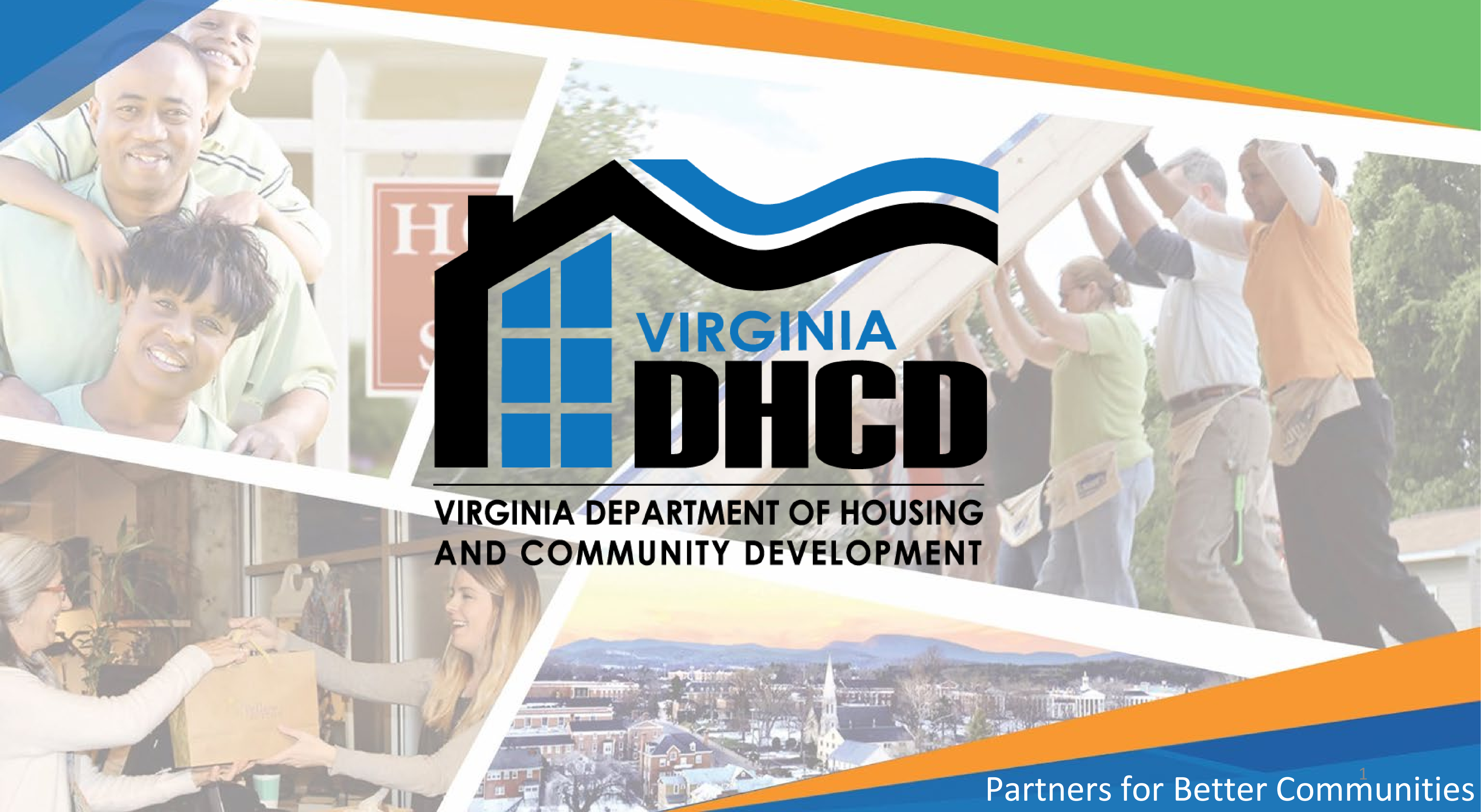


VIRGINIA DHCD

VIRGINIA DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT

Partners for Better Communities

2024 Code Development Cycle

General Information

DHCD Staff

Jeff Brown, Deputy Director of Building and Fire Regulation

Paul Messplay, Code & Regulation Specialist

Florin Moldovan, Code & Regulation Specialist

Chris Scott, Code & Regulation Specialist

2024 Code Development Cycle (tentative dates)

April 1st: cdpVA opened for submission of code change proposals

June: Notices of Intended Regulatory Action (NOIRAs) published

June - July: Study Groups and Sub-Workgroups begin meeting

July 14th: BHCD Public Hearing (with VFSB for SFPC)

October 8th: Deadline for submission of proposals for the 2024 CDC

July – November 2025: Stakeholder Workgroup meetings on proposals

March 2026: BHCD meets to consider proposals

September 2026: BHCD meets to consider proposed regulations

March 2027: BHCD meets to consider final regulations

October 2027: 2024 Virginia Codes Effective

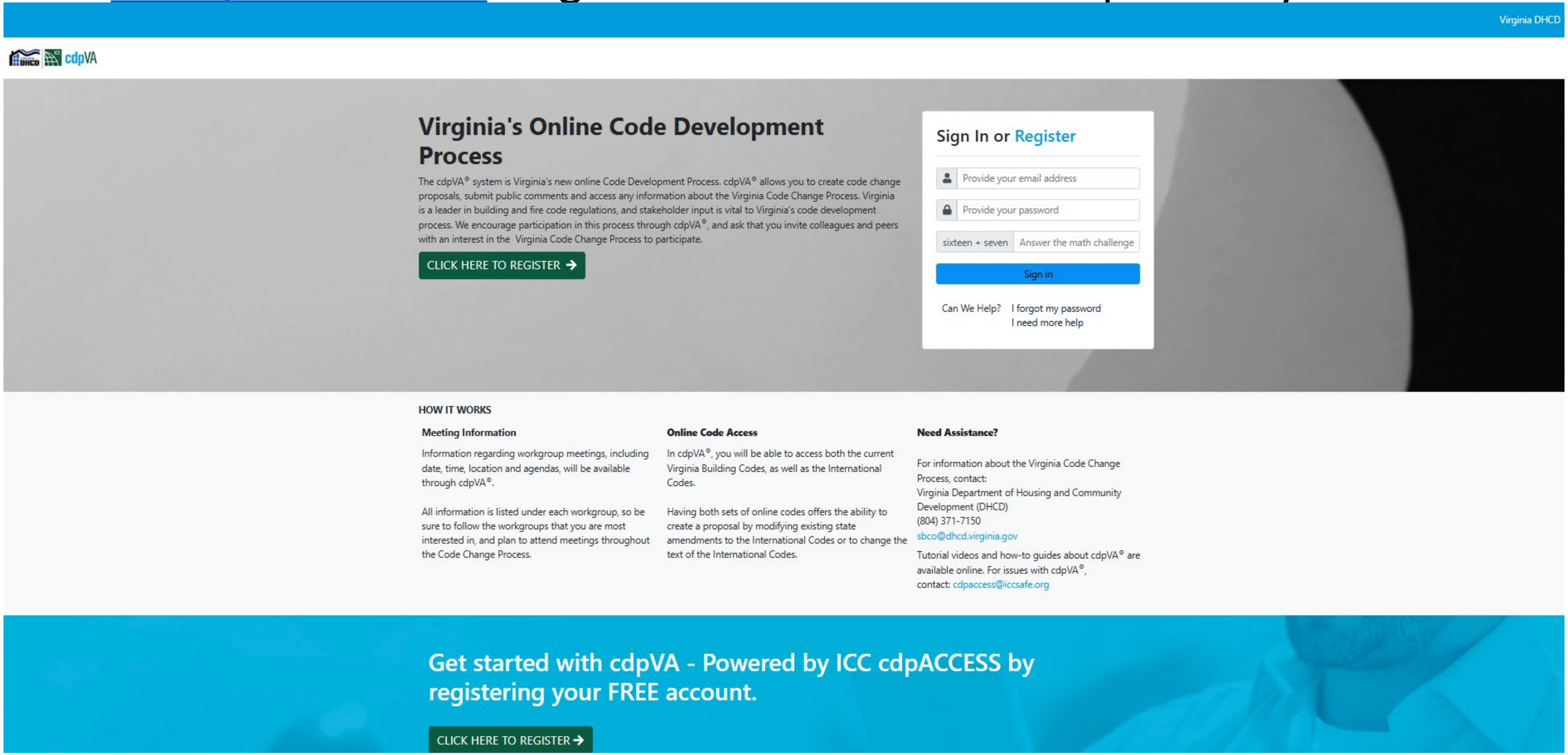
Access to Codes

codes.iccsafe.org/codes/Virginia

Free Online Access to Virginia and ICC Code books

cdpVA

va.cdpaccess.com Virginia’s online code development System



LINKS

Code Development Process Flowchart

2024 Code Development Cycle Documents

2021 Code Development Cycle Documents

2024 Code Development Cycle Webpage

https://www.dhcd.virginia.gov/2024-code-development-cycle

- Workgroup documents (agendas, meeting summaries, etc.)
- Sub-workgroup documents (agendas, meeting summaries, etc.)
- Study Group documents (agendas, meeting summaries, etc.)
- General Information (memos, schedules, process flow chart, etc.)
- 2024 Base Documents

DHCD Base Documents

https://www.dhcd.virginia.gov/2024-code-development-cycle

WORKGROUP DOCUMENTS General Stakeholder Workgroup Meeting Agenda - July 29, 2025	**SINGLE EXIT STAIR STUDY GROUP** June 24, 2025 Single Exit Stair Study Group Meeting: Agenda | Summary | Documents
EXPEDITING PERMITS AND COS STUDY GROUP June 25, 2025 Expediting Permits and COs Study Group Meeting: Agenda | Summary | Documents	**HEATING & COOLING STUDY GROUP** June 23, 2025 Heating and Cooling Study Group Meeting: Agenda | Summary | Documents
SFPC SUB-WORKGROUP July 8, 2025 SFPC Sub-Workgroup Meeting: Agenda | Summary | Documents	**ENERGY SUB-WORKGROUP** July 9, 2025 Energy Sub-Workgroup Meeting: Agenda | Summary | Documents
MEMOS NOIRA Stakeholder Memo Code Development Cycle Stakeholder Memo - April 1,	**BASE DOCUMENTS** 2024 IBSR Base Document

General Stakeholder Workgroup

- All meetings are open to attendance and participation by anyone
- Review and discuss all submitted code change proposals, including all proposals and recommendations from Study Groups and Sub-Workgroups
- A workgroup recommendation is determined for each proposal and the recommendation is provided to the Board of Housing and Community Development
- Workgroup recommendations are classified as follows:

Consensus for Approval: No workgroup participant expressed opposition to the proposal

Non-Consensus: Any workgroup participant expressed opposition to the proposal

General Stakeholder Workgroup

- Initial General Stakeholder Workgroup meeting(s) will be in July 2025
- Proposal Submission Deadline for the 2024 Code Development Cycle
  October 8, 2025
- Final General Stakeholder Workgroup meeting(s) will be mid-November

Study Groups

- Study specific topics that require additional review and discussion
- Identify areas of consensus and disagreement
- Determine if code change proposals or other solutions are appropriate
- May review proposals, provide analysis, make recommendations, and/or develop code change proposals
- All code change proposals and any recommendations on code change proposals are reviewed by the General Workgroups and assigned a Workgroup recommendation prior to BHCD consideration

Sub-Workgroups

- Review and discuss code change proposals within their subject matter prior to the proposals being considered by the General Stakeholder Workgroup
- Address questions and concerns related to proposals to identify areas for compromise, where appropriate, in an effort to reach consensus
- May develop new code change proposals as determined appropriate
- Members may support proposals by joining the proposal as a proponent
- All code change proposals are reviewed by the General Workgroups and assigned a Workgroup recommendation prior to BHCD consideration

2024 Study Groups and Sub-Workgroups

2024 Code Development Cycle Study Groups:

- Single Exit Stair Buildings
- Expediting Permits and Certificates of Occupancy
- Heating and Cooling
- Unsafe Structures

2024 Code Development Cycle Sub-workgroups:

- Energy
- Statewide Fire Prevention Code

Division of Building and Fire Regulations

State Building Codes Office

codedevelopment@dhcd.virginia.gov

804-371-7150

B105.1-24

VCC: 105.1; VPMC: 104.4; SFPC: 105.1.1

Proponents: Ronald Clements, representing Chesterfield County Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Construction Code

Revise as follows:

105.1 Appointment of building official. Every *local building department* shall have a building official as the executive official in charge of the department. The building official shall be appointed in a manner selected by the *local governing body*. ~~After permanent~~ After appointment, the building official shall not be removed from office except for cause after having been afforded a full opportunity to be heard on specific and relevant charges by and before the appointing authority. *DHCD* shall be notified by the appointing authority within 30 days of the appointment or release of ~~a permanent or acting~~ the building official.

> **Note:** Building officials are subject to sanctions in accordance with the *VCS*.

2021 Virginia Property Maintenance Code

Revise as follows:

104.4 Local enforcing agency. In jurisdictions enforcing this code, the local governing body shall designate the agency within the local government responsible for such enforcement and appoint a *code official*. The local governing body may also utilize technical assistants to assist the *code official* in the enforcement of this code. ~~A permanently~~ The appointed *code official* shall not be removed from office except for cause after having been afforded a full opportunity to be heard on specific and relevant charges by and before the appointing authority. DHCD shall be notified by the appointing authority within 30 days of the appointment or release of ~~a permanent or acting~~ the *code official* and within 60 days after retaining or terminating a technical assistant.

> **Note:** *Code officials* and technical assistants are subject to sanctions in accordance with the VCS.

2021 Virginia Statewide Fire Prevention Code

Revise as follows:

105.1.1 Appointment. The fire official shall be appointed in a manner selected by the *local government* having jurisdiction. After ~~permanent~~ appointment, the fire official shall not be removed from office except for cause after having been afforded a full opportunity to be heard on specific and relevant charges by and before the appointing authority.

Reason Statement:

VBCOA supports this code change.

This code change is submitted on behalf of Delegate Delores Oats. During the 2024 legislative session, HB1092 was introduced by Delegate Oats that intended to limit building official appointments to 10 years and make it clear that they were not permanent appointments. The bill was submitted due to concerns that though the appointment code provision provides for the removal of the building official with cause, the statement that the appointment was permanent could make it difficult to remove the building official even with cause. The bill was left in committee after the 2024 session, and we offered to assist Delegate Oats with submission of a code change for the 2024 Virginia code cycle. This code change does not limit the appointment to 10 years but removes the word “permanent” from the third sentence, clarifying that the building official can be removed with cause. Since the building official can be removed with cause, it is not a permanent appointment in the sense that the building official is immune from removal. The maintenance and fire officials were added for consistency.

Cost Impact: The code change proposal will not increase or decrease the cost

This provision does not impact the cost of construction.

B108.2-24

VCC: 108.2

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2021 Virginia Construction Code

Revise as follows:

108.2 Exemptions from application for permit. Notwithstanding the requirements of Section 108.1 , application for a permit and any related inspections shall not be required for the following; however, this section shall not be construed to exempt such activities from other applicable requirements of this code. In addition, when an *owner* or an *owner's* agent requests that a permit be issued for any of the following, then a permit shall be issued and any related inspections shall be required.

1. Installation of wiring and *equipment* that (i) operates at less than 50 volts, (ii) is for broadband communications systems, (iii) is exempt under Section 102.3(1) or 102.3(4) , or (iv) is for monitoring or automation systems in dwelling units, except when any such installations are located in a plenum, penetrate fire-rated or smoke-protected *construction* or are a component of any of the following:
   1.1. Fire alarm system.
   1.2. Fire detection system.
   1.3. Fire suppression system.
   1.4. Smoke control system.
   1.5. Fire protection supervisory system.
   1.6. Elevator fire safety control system.
   1.7. Access or egress control system or delayed egress locking or latching system.
   1.8. Fire damper.
   1.9. Door control system.
2. One-story detached *structures* used as tool and storage sheds, playhouses or similar uses, provided the building area does not exceed 256 square feet (23.78 m^2) and the *structures* are not classified as a Group F-1 or H occupancy.
3. Detached prefabricated *buildings* housing the *equipment* of a publicly regulated utility service, provided the floor area does not exceed 150 square feet (14 m^2).
4. Tents or air-supported *structures*, or both, that cover an area of 900 square feet (84 m^2) or less, including within that area all connecting areas or spaces with a common means of egress or entrance, provided such tents or *structures* have an occupant load of 50 or less persons.
5. Fences of any height unless required for pedestrian safety as provided for by Section 3306 , or used for the barrier for a *swimming pool*.
6. Concrete or masonry *walls*, provided such *walls* do not exceed 6 feet (1829 mm) in height above the finished grade. Ornamental column caps shall not be considered to contribute to the height of the *wall* and shall be permitted to extend above the 6-foot (1829 mm) height measurement.
7. Retaining *walls* supporting less than 3 feet (914 mm) of unbalanced fill that are not constructed for the purpose of impounding Class I, II or III-A liquids or supporting a surcharge other than ordinary unbalanced fill.
8. *Swimming pools* that have a surface area not greater than 150 square feet (13.95 m^2) and are less than 24 inches (610 mm) deep.
9. Signs under the conditions in Section H101.2 of Appendix H.

10. Replacement of above-ground existing LP-gas containers of the same capacity in the same location and associated regulators when installed by the serving gas supplier.
11. Flagpoles 30 feet (9144 mm) or less in height.
12. Temporary ramps serving dwelling units in Groups R-3 and R-5 occupancies where the height of the entrance served by the ramp is no more than 30 inches (762 mm) above grade.
13. *Construction* work deemed by the building official to be minor and ordinary and which does not adversely affect public health or general safety.
14. Ordinary repairs that include the following:
    - 14.1. Replacement of windows and doors with windows and doors of similar operation and opening dimensions that do not require changes to the existing framed opening and that are not required to be fire rated in Group R-2 where serving a single dwelling unit and in Groups R-3, R-4 and R-5.
    - 14.2. Replacement of plumbing fixtures and well pumps in all groups without alteration of the water supply and distribution systems, sanitary drainage systems or vent systems.
    - 14.3. Replacement of general use snap switches, dimmer and control switches, 125 volt-15 or 20 ampere receptacles, luminaires (lighting fixtures) and ceiling (paddle) fans in Group R-2 where serving a single dwelling unit and in Groups R-3, R-4 and R-5.
    - 14.4. Replacement of mechanical appliances, provided there is no refrigerant classification change and such *equipment* is not fueled by gas or oil in Group R-2 where serving a single-family dwelling and in Groups R-3, R-4 and R-5.
    - 14.5. Replacement of an unlimited amount of roof covering or siding in Group R-3, R-4 or R-5, provided the *building* or *structure* is not in an area where the nominal design wind speed is greater than 100 miles per hour (44.7 meters per second) and replacement of 100 square feet (9.29 m^2) or less of roof covering in all groups and all wind zones.
    - 14.6. Replacement of 256 square feet (23.78 m^2) or less of roof decking in Group R-3, R-4 or R-5 unless the decking to be replaced was required at the time of original *construction* to be fire-retardant-treated or protected in some other way to form a fire-rated *wall* termination.
    - 14.7. Installation or replacement of floor finishes in all occupancies.
    - 14.8. Replacement of Class C interior *wall* or ceiling finishes installed in Groups A, E and I and replacement of all classes of interior *wall* or ceiling finishes in other groups.
    - 14.9. Installation or replacement of cabinetry or trim.
    - 14.10. Application of paint or wallpaper.
    - 14.11. Other repair work deemed by the building official to be minor and ordinary which does not adversely affect public health or general safety.
15. Crypts, mausoleums and columbaria structures not exceeding 1,500 square feet (139.35 m^2) in area if the *building* or *structure* is not for occupancy and used solely for the interment of human or animal remains and is not subject to special inspections.
16. Billboard safety upgrades to add or replace steel catwalks, steel ladders, or steel safety cable.

Exceptions:

1. Application for a permit may be required by the building official for the installation of replacement siding, roofing and windows in *buildings* within a historic district designated by a *locality* pursuant to §15.2-2306 of the Code of Virginia.
2. Application for a permit may be required by the building official for any items exempted in this section that are located in a *special flood hazard area.*

Reason Statement:

The 2021 code cycle introduced new and revised code provisions to support the transition away from high global warming potential (GWP) refrigerants, in line with national phasedown efforts mandated by the EPA. One significant change is the requirement that refrigerants for heating and cooling now have a GWP of 700 or less. In residential applications, this typically means the use of refrigerants classified as A2L which are mildly flammable with a lower burning velocity.

Due to the flammable nature of A2L refrigerants, specific safety measures are now required under the code to mitigate associated risks. However, the residential code currently lacks clear language specifying that the replacement of a system's refrigerant with a different classification, especially a shift from non-flammable (A1) to flammable (A2L), is not considered a like-for-like replacement.

This proposal seeks to clarify that a permit is required when a heating or cooling system undergoes a refrigerant conversion. This includes, but is not limited to, replacing an A1 refrigerant with an A2L refrigerant, due to the significant safety implications and code compliance considerations. Such work must be permitted and inspected to ensure proper adherence to the applicable safety provisions in the mechanical code.

Cost Impact: The code change proposal will not increase or decrease the cost

The cost of construction will not increase if this proposal is accepted. This proposal is a clarification that a permit is required for a refrigerant change.

B115.2-24

VCC: 115.2

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Construction Code

Revise as follows:

115.2 Notice of violation. The building official ~~shall~~ is authorized to issue a written notice of violation to the responsible party or *permit holder* if any violations of this code or any directives or orders of the building official have not been corrected or complied with within a reasonable time. ~~The building official may also issue a notice of violation to other persons found to be responsible in addition to the *permit holder*. If the violations, directives, or orders involve work without a permit, the notice of violation shall be issued to the responsible party. The notice shall~~ The notice shall reference the code section upon which the notice is based and direct the correction of the violation or the compliance with such directive or order and specify a reasonable time period within which the corrections or compliance must occur. The notice shall be issued by either delivering a copy by mail to the last known address of the *permit holder* or responsible party, by delivering the notice in person, by leaving it in the possession of any person in charge of the premises, or by posting the notice in a conspicuous place if the person in charge of the premises cannot be found. The notice of violation shall indicate the right of appeal by referencing the appeals section. When the *owner* of the *building* or *structure* or the tenants of such *building* or *structure* are not the party to whom the notice of violation is issued, then a copy of the notice shall also be delivered to the *owner* or tenants.

> **Note:** A notice of unsafe *building* or *structure* for *structures* that become unsafe during the *construction* process are issued in accordance with Section 118 .

Reason Statement:

This proposal is supported by VBCOA.

This proposal is an effort to promote the “Virginia Way” and grant building officials needed flexibility to resolve issues and gain compliance. Currently the NOV provisions mandate that the building official issue an NOV if code violations have not been corrected, regardless of the circumstances. For instance, if a house is under construction and the contractor goes out of business before completing the house, there may be outstanding code violations, but the house is left in a safe and secure manor while awaiting purchase and/or completion by a new contractor. Why in that case should we be compelled to issue the now out of business contractor an NOV? This proposal does not take away the building official’s ability and authority to issue an NOV, it simply gives the building official the flexibility to make decisions based on the specific circumstance. The second part of this proposal is to give the building official the flexibility to determine the appropriate party to whom to issue the NOV. The section was changed from responsible party to permit holder. This proposal retains the reference to the permit holder if that is the appropriate party to receive the NOV but adds the ability for the building official to issue it to the responsible party if not the permit holder. Currently if the responsible party is not the permit holder the code official is mandated to issue the NOV to the permit holder. Additionally, by adding responsible party to the first sentence it relieves the need to for the second and third sentences of the code provision helping to reduce the code section, making it more concise and consistent with the governor’s executive order.

Note: A separate code change is being submitted regarding VCC Section 118, which proposes to delete the note to this section. If that code change is approved it causes no effect to this code change and is supported by this proponent.

Cost Impact: The code change proposal will not increase or decrease the cost

Who is served a notice does not affect cost of construction.

B115.2(2)-24

VCC: 115.2

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Construction Code

Revise as follows:

115.2 Notice of violation. The building official shall issue a written notice of violation to the *permit holder* if any violations of this code or any directives or orders of the building official have not been corrected or complied with within a reasonable time. The building official may also issue a notice of violation to other persons found to be responsible in addition to the *permit holder*. If the violations, directives, or orders involve work without a permit, the notice of violation shall be issued to the responsible party. The notice shall reference the code section upon which the notice is based and direct the correction of the violation or the compliance with such directive or order and specify a reasonable time period within which the corrections or compliance must occur. The notice shall be issued by either delivering a copy by mail to the last known address of the *permit holder* or responsible party, by delivering the notice in person, by leaving it in the possession of any person in charge of the premises, ~~or~~ by electronic service to the *permit holder* or responsible party, or by posting the notice in a conspicuous place if the person in charge of the premises cannot be found. The notice of violation shall indicate the right of appeal by referencing the appeals section. When the *owner* of the *building* or *structure* or the tenants of such *building* or *structure* are not the party to whom the notice of violation is issued, then a copy of the notice shall also be delivered to the *owner* or tenants.

> **Note:** A notice of unsafe *building* or *structure* for *structures* that become unsafe during the *construction* process are issued in accordance with Section 118 .

Reason Statement:

VBCOA supports this code change.

Electronic service has become an acceptable delivery method for legal documents. This service method was added to Section 111.2 of the Virginia Statewide Fire Prevention Code in the 2021 edition. Section 105.4 of the VPMC does not specify specific delivery methods so electronic service is already acceptable for notices of violation issued under the VPMC.

Cost Impact: The code change proposal will not increase or decrease the cost

Method of service delivery does not impact cost of construction.

B118.4-24

VCC: 115.2, 118.3.1, 118.4, 118.5, 118.4.1 (New), 118.6, 118.7

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Construction Code

Revise as follows:

115.2 Notice of violation. The building official shall issue a written notice of violation to the *permit holder* if any violations of this code or any directives or orders of the building official have not been corrected or complied with within a reasonable time. The building official may also issue a notice of violation to other persons found to be responsible in addition to the *permit holder*. If the violations, directives, or orders involve work without a permit, the notice of violation shall be issued to the responsible party. The notice shall reference the code section upon which the notice is based and direct the correction of the violation or the compliance with such directive or order and specify a reasonable time period within which the corrections or compliance must occur. The notice shall be issued by either delivering a copy by mail to the last known address of the *permit holder* or responsible party, by delivering the notice in person, by leaving it in the possession of any person in charge of the premises, or by posting the notice in a conspicuous place if the person in charge of the premises cannot be found. The notice of violation shall indicate the right of appeal by referencing the appeals section. When the *owner* of the *building* or *structure* or the tenants of such *building* or *structure* are not the party to whom the notice of violation is issued, then a copy of the notice shall also be delivered to the *owner* or tenants. ~~**Note:** A notice of unsafe *building* or *structure* for *structures* that become unsafe during the *construction* process are issued in accordance with Section 118 .~~

~~**118.3.1**~~<u>**118.4**</u> **Vacating ~~unsafe~~ <u>the</u> building or structure.** If the building official determines there is actual and immediate danger to the occupants or public, ~~or when life is endangered by the occupancy of an unsafe~~<u>and the</u> *building* or *structure* <u>*under construction is occupied*</u>, the building official shall be authorized to order the occupants to immediately vacate the ~~unsafe~~ *building* or *structure*. When ~~an unsafe~~ <u>the</u> *building* or *structure* is ordered to be vacated, the building official shall ~~post a notice at each entrance that reads as follows: "This Building (or Structure) is Unsafe and its Occupancy (or Use) is Prohibited by the Building Official."~~<u>include the order in the correction notice, notice of violation, or issue a separate order.</u>~~After posting, occupancy or use of the unsafe *building* or *structure* s hall be prohibited except when authorized to enter to conduct inspections, make required repairs, or as necessary to demolish the *building* or *structure*.~~

Delete without substitution:

~~**118.4 Posting of notice.** The notice shall be sent by registered or certified mail to the last known address of the responsible party and a copy of the notice shall be posted in a conspicuous place on the premises.~~

~~**118.5 Posting of placard.** In the case of an unsafe *building* or *structure*, if the notice is not complied with, a placard with the following wording shall be posted at the entrance to the *building* or *structure*:~~

> ~~"This Building (or Structure) is Unfit for Habitation and its Use or Occupancy has been Prohibited by the Building Official."~~

~~After an unsafe *building* or *structure* is placarded, entering the unsafe *building* or *structure* shall be prohibited except as authorized by the building official to make inspections, to perform required repairs, or to demolish the unsafe *building* or *structure*. In addition, the placard shall not be removed until the unsafe building or structure is determined by the building official to be safe to occupy. The placard shall not be defaced.~~

Add new text as follows:

<u>**118.4.1** **Posting of placard.** If the building or structure has been issued an order to vacate a placard shall be posted with the following wording at each entrance to the structure: "THIS STRUCTURE IS AN IMMEDIATE THREAT TO PUBLIC SAFETY AND ITS USE OR</u>

OCCUPANCY HAS BEEN PROHIBITED BY THE BUILDING OFFICIAL." After a structure is placarded, entering the structure shall be prohibited except as authorized by the building official to make inspections, to perform required repairs or to demolish the structure. The placard shall not be tampered with, nor shall it be removed until the structure is determined by the building official to no longer be a threat to public safety.

Revise as follows:

~~118.6~~118.5 **Emergency repairs and demolition.** To the extent permitted by the *locality*, the building official may authorize emergency repairs or securing of the site when it is determined that there is an imminent threat to the life and safety of the public. The building official shall be permitted to authorize the necessary work to make the *structure* temporarily safe whether or not legal action to compel compliance has been instituted.

In addition, if the notice of violation included an order to demolish the *structure* and the demolition has not occurred in the time period stipulated, the building official shall be permitted to cause the ~~unsafe~~ *structure* to be demolished. In accordance with §§ 15.2-906 and 15.2-1115 of the Code of Virginia, the legal counsel of the *locality* may be requested to institute appropriate action against the property *owner* to recover the costs associated with any such emergency repairs or demolition and every such charge that remains unpaid shall constitute a lien against the property on which the emergency repairs or demolition were made and shall be enforceable in the same manner as provided in Articles 3 (§ 58.1-3940 et seq.) and 4 (§ 58.1-3965 et seq.) of Chapter 39 of Title 58.1 of the Code of Virginia.

> **Note:** Building officials and local governing bodies should be aware that other statutes and court decisions may impact on matters relating to demolition, in particular whether newspaper publication is required if the *owner* cannot be located and whether the demolition order must be delayed until the *owner* has been given the opportunity for a hearing.

~~118.7~~118.6 **Closing of streets.** When necessary for public safety, the building official shall be permitted to order the temporary closing of sidewalks, streets, public ways, or premises adjacent to a *structure* that has become a threat to public safety during *construction*.

Reason Statement:

This proposal is supported by VBCOA.

In general, this code change removes some remaining old VPMC terminology references to "unsafe buildings" replacing terminology where needed to be consistent with the threat to public safety terminology established in 118.1, and further simplifies and condenses the section.

115.2- The note to Section 115.2 is proposed for deletion as Section 118.3 has the cross reference back to 115 and the note uses the old unsafe terminology.118.3.1 (proposed 118.4)- The proposed revision removes some references to the old unsafe terminology and the added text clearly states how the order to vacate is to be provided either included with the correction notice or notice of violation, or as a separate order.
Posting 118.3.1, 118.4, 118.5 (proposed 118.4.1))- The current provisions have two different methods of posting the notice to vacate, a hold-over from past VPMC methodology that has also been cleaned up in the VPMC. It is convoluted in that you post a notice to vacate, then if that notice is not complied with you post a placard. The deleted text removes the two posting methods, and the new text gives a single clear requirement for posting the structure with a placard; and the placard terminology has been corrected.

The section has been renumbered to accommodate the proposed changes.

Cost Impact: The code change proposal will not increase or decrease the cost
This code change is editorial and affects administrative processes, and does not impact construction or cost of construction.

B119.5-24

VCC: 119.5; VPMC: 107.5

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Construction Code

Revise as follows:

119.5 Right of appeal; filing of appeal application. Any person aggrieved by the *local building department's* application of the USBC or the refusal to grant a modification to the provisions of the USBC may appeal to the *LBBCA*. The applicant shall submit a written request for appeal to the *LBBCA* within 30 calendar days of the receipt of the decision being appealed. The application shall contain the name and address of the *owner* of the *building* or *structure* and, in addition, the name and address of the person appealing, when the applicant is not the *owner*. A copy of the building official's decision shall be submitted along with the application for appeal and maintained as part of the record. The application shall be marked by the *LBBCA* to indicate the date received. Failure to submit an application for appeal within the time limit established by this section shall constitute acceptance of a building official's decision. <u>Reaffirmation of a prior code decision does not constitute a new application of code subject to appeal.</u>

> **Note:** To the extent that a decision of a building official pertains to amusement devices there may be a right of appeal under the *VADR*.

2021 Virginia Property Maintenance Code

Revise as follows:

107.5 Right of appeal; filing of appeal application. Any person aggrieved by the local enforcing agency's application of this code or the refusal to grant a modification to the provisions of this code may appeal to the LBBCA. The applicant shall submit a written request for appeal to the LBBCA within 14 calendar days of the receipt of the decision being appealed. The application shall contain the name and address of the *owner* of the *building* or *structure* and, in addition, the name and address of the person appealing, when the applicant is not the owner. A copy of the *code official's* decision shall be submitted along with the application for appeal and maintained as part of the record. The application shall be marked by the LBBCA to indicate the date received. Failure to submit an application for appeal within the time limit established by this section shall constitute acceptance of a *code official's* decision. <u>Reaffirmation of a prior code decision does not constitute a new application of code subject to appeal.</u>

Reason Statement:
This code change is supported by VBCOA.

Is the response to a request to reaffirm a prior application of code, a new application of code, and subject to appeal with a new 30-day window? This has been a debated topic at several TRB meetings. A case I was involved in resulted in a 5-5 split vote that had to be decided by the acting chair. As an example: an inspection is performed and rejected; the contractor that performed the rejected work waits 60 days, then decides to file an appeal. The contractor is informed 30 days has passed so the contractor asks the inspector to come back out and reaffirm that the work is in violation. The inspector re-inspects and reaffirms that it is still in violation just like it was 60 days ago; the contractor then appeals the new decision. This is a simple way to get around the 30-day limit. Another example: Homeowner purchases a house 5 years after the CO was issued and final inspection performed. He asks the inspector to come out and look at what the homeowner thinks is a code violation. The inspector says it was not a violation 5 years ago when it was inspected. The homeowner appeals the new decision.

This code change fixes this loophole and does not allow a request for reaffirmation to be used to reset the 30-day limit. By using the term reaffirmation, this does not limit the ability to appeal the latest decision if it is different from what was initially determined, and thereby being a new application of code.

Reaffirmation dictionary definition- A reassertion or confirmation of a fact or belief. The action of reasserting or confirming something.

Cost Impact: The code change proposal will not increase or decrease the cost

This is an administrative change that does not impact construction cost.

PM105.2-24

VPMC: 105.2

Proponents: Matthew Mertz, Fairfax County Department of Code Compliance, representing Fairfax County, Property Maintenance Official, Department of Code Compliance (matthew.mertz@fairfaxcounty.gov)

2021 Virginia Property Maintenance Code

Revise as follows:

105.2 Notices, reports and orders. Upon findings by the *code official* that violations of this code exist, the *code official* shall issue a correction notice or notice of violation to the *owner*, *tenant* or the person responsible for the maintenance of the *structure*; or, a notice of *unsafe structure* in accordance with Section 106 when a *building* or *structure* is determined by the *code official* to be an *unsafe structure*. Work done to correct violations of this code subject to the permit, inspection and approval provisions of the VCC shall not be construed as authorization to extend the time limits established for compliance with this code. When the *owner* is not the responsible party to whom the notice of violation or correction notice is issued, a copy of the notice shall also be delivered to the *owner*~~.~~. A written notice of violation shall be served either by delivering a copy of same to such persons by mail to the last known post office address, by delivering in person or by delivering it to and leaving it in the possession of any person in charge of the premises, or in the case such person is not found upon the premises, by affixing a copy thereof in a conspicuous space at the entrance door or avenue of access, or by transmitting to a valid electronic mailbox. Such procedure shall be deemed the equivalent of personal notice.

Reason Statement: Currently, the VPMC doesn't provide instruction on notice of violation service methods. This would align service methods in the VPMC with the SFPC, an excerpt of which is attached.

Cost Impact: The code change proposal will not increase or decrease the cost

There is no anticipated impact on costs.

FP202-24

SFPC: SECTION 202

Proponents: Gerry Maiatico, County of Warren & Virginia Fire Prevention Association, representing Virginia Fire Prevention Association (gmaiatico@warrencountyfire.com)

2021 Virginia Statewide Fire Prevention Code

Revise as follows:

MOBILE FOOD PREPARATION VEHICLES. Vehicles, covered trailers, carts, and enclosed trailers, boats and watercraft, or other moveable devices capable of being able to be occupied by persons during cooking operations and that contain cooking equipment that utilize open flames or are capable of producing smoke or grease laden vapors for the purpose of preparing and serving food to the public. Vehicles, boats or watercraft used for private recreation shall not be considered mobile food preparation vehicles.

Reason Statement: Multiple localities have experienced boats and watercraft being converted to a food preparation type vehicle. The current definition of a mobile food preparation vehicle is not clear as to if this type of apparatus is included. This proposed langaue provides that clarity.

Cost Impact: The code change proposal will not increase or decrease the cost

No impact

FP601.2-24

IFC: 601.2; SFPC: 110.1; IFC: SECTION 202 (New)

Proponents: Gerry Maiatico, County of Warren & Virginia Fire Prevention Association, representing Virginia Fire Prevention Association (gmaiatico@warrencountyfire.com)

2024 International Fire Code

Revise as follows:

601.2 Hazard abatement. Operations or conditions deemed unsafe or hazardous by the *fire code official* shall be abated. Equipment, appliances, materials and systems that are modified or damaged and constitute an electrical shock or fire hazard shall not be used. When in the fire code official's opinion, there is actual or potential danger to the occupants or extreme risk of fire to the property due to the improper installation, use and/or maintenance of equipment, appliances, or the building *utilities* and violations of this code have been found, the fire code official may order the *utilities* service to be disconnected or terminated to the affected equipment, appliance, building or portions thereof. Abatement of hazards, repairs or reconnection of *utilities* to the affected equipment, appliance, building or portions thereof shall be done in accordance with the applicable building code.

2021 Virginia Statewide Fire Prevention Code

Revise as follows:

110.1 General. The fire official shall order the following dangerous or hazardous conditions or materials found to be noncompliant with provisions found within the subsequent sections of this code to be removed or remedied in accordance with the SFPC:

1. Dangerous conditions which are liable to cause or contribute to the spread of fire in or on said premises, *building* or structure, or to endanger the occupants thereof.
2. Conditions which would interfere with the efficiency and use of any fire protection equipment.
3. Obstructions to or on fire escapes, stairs, passageways, doors or windows, which are liable to interfere with the egress of occupants or the operation of the fire department in case of fire.
4. Accumulations of dust or waste material in air conditioning or ventilating systems or grease in kitchen or other exhaust ducts.
5. Accumulations of grease on kitchen cooking equipment, or oil, grease or dirt upon, under or around any mechanical equipment.
6. Accumulations of rubbish, waste, paper, boxes, shavings, or other combustible materials, or excessive storage of any combustible material.
7. Hazardous conditions arising from defective or improperly used or installed ~~electrical wiring, equipment~~ equipment, appliances or ~~appliances.~~ any portion of a building's utilities.
8. Hazardous conditions arising from defective or improperly used or installed equipment for handling or using combustible, explosive or otherwise hazardous materials.
9. Dangerous or unlawful amounts of combustible, explosive or otherwise hazardous materials.
10. All equipment, materials, processes or operations which are in violation of the provisions and intent of this code.

2024 International Fire Code

Add new text as follows:

New Definition. Utilities. The essential services that enable a building, equipment or an appliance to function effectively.

Reason Statement:

Section 110.1 (7) of the SFPC provides language to render a unsafe condition due to *hazardous conditions arising from defective or improperly used or installed electrical wiring, equipment, or appliances.* There are no immediate actions outside of section "601.2 Hazard Abatement" and "601.2.1 Correction of Unsafe Condition" that provides provisions for immediate safety actions such as securing and/or terminating power or other essential services to the equipment, appliance, building or portions thereof. Only the language “shall not be used”.

This proposal will afford the Fire Code Official to cause for the immediate termination and/or disconnection of a buildings utilities for the effected equipment, appliance, building or portions thereof.

This proposal defines "utilities" while amending the unsafe structure 110.1 (7) to include all the buildings utilities and not limited this provision to electrical in nature.

Similar language is included in section 111.1 if the IFC, which is deleted and replaced with VA Chapter 1. This proposal also ensures that all corrective actions and/or reconnection of the utilities is done so in accordance with the applicable building code.

Cost Impact: The code change proposal will not increase or decrease the cost

No impact forseen

FP3101.1-24

SFPC: CHAPTER 31, SECTION 3101, 3101.1, SECTION 3103, 3103.1, 3103.2, 3103.2.1, 3103.3, 3103.3.1, 3103.4, 3103.5, 3103.6, 3103.7, 3103.7.1, 3103.8, 3103.8.1, 3103.8.2, 3103.8.3, 3103.8.4, 3103.8.5, 3103.8.6, 3103.9, 3103.9.1, 3103.9.2, 3103.9.3, 3103.10, 3103.10.1, 3103.10.2, 3103.10.3, 3103.10.4, 3103.11, 3103.12, 3103.12.1, 3103.12.2, TABLE 3103.12.2, 3103.12.3, 3103.12.4, 3103.12.5, 3103.12.5.1, 3103.12.6, 3103.12.6.1, 3103.12.7, 3103.12.8, SECTION 3104, 3104.1, 3104.2, 3104.3, 3104.4, SECTION 3105, 3105.1, 3105.2, 3105.3, 3105.4, 3105.5, 3105.6, 3105.6.1, 3105.6.2, 3105.7, 3105.8, 3105.9

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Statewide Fire Prevention Code

Revise as follows:

CHAPTER 31
TENTS, ~~TEMPORARY SPECIAL EVENT~~ MEMBRANE STRUCTURES ~~AND OTHER MEMBRANE STRUCTURES~~, AND OUTDOOR ASSEMBLY EVENTS

SECTION 3101
GENERAL

3101.1 Scope. Tents, temporary special event structures, and membrane structures shall comply with this chapter. The provisions of Section 3103 are applicable only to temporary tents and membrane ~~structures. The provisions of Section 3104 are applicable to temporary and permanent tents and membrane structures.~~structures.

SECTION 3103
TEMPORARY TENTS AND MEMBRANE STRUCTURES

3103.1 General. All temporary tents and membrane structures shall comply with this section.

Delete without substitution:

~~**3103.2 Approval required.** Tents and membrane structures having an area in excess of 900 square feet (84 m^2) shall not be erected, operated or maintained for any purpose without first obtaining a permit and approval from the *fire code official* in accordance with Table 107.2 .~~

~~**3103.2.1 Multiple tents.** The aggregate area of multiple tents separated by less than 12 feet (3658 mm) shall not exceed 900 square feet (84 m^2) unless *approved* in accordance with Section 3103.2 .~~

3103.3 Outdoor assembly event. For the purposes of this chapter, an outdoor assembly event shall include a circus, carnival, tent show, theater, skating rink, dance hall or other place of assembly in or under which persons gather for any purpose

3103.3.1 Special amusement area. (Section deleted.)

3103.4 Permits. Permits shall be required as set forth in Section 107.2 .

~~**3103.5 Use period.** Temporary *tents*, air-supported, airinflated or tensioned *membrane structures* shall not be erected for a period of more than 180 days within a 12-month period on a single premises.~~

~~**3103.6 Construction documents.** A detailed site and floor plan for *tents* or *membrane structures* with an *occupant load* of 50 or more shall be provided with each application for approval. The *tent* or *membrane structure* floor plan shall indicate details of the *means of egress* facilities, seating capacity, arrangement of the seating and location and type of heating and electrical equipment. The *construction documents* shall include an analysis of structural stability.~~

Revise as follows:

3103.7 Inspections. The entire *tent*, air-supported, airinflated or tensioned *membrane structure* system shall be inspected at regular intervals, but not less than two times per permit use period, by the permittee, *owner* or agent to determine that the installation is maintained in accordance with ~~this chapter.~~the this chapter and the appliable building code.

Exception: Permit use periods of less than 30 days.

3103.7.1 Inspection report. Where required by the *fire code official*, an inspection report shall be provided ~~and shall consist of maintenance, anchors and fabric inspections.~~by the permittee, owner, or agent documenting performance of the inspections required per Section 3103.7.

3103.8 Access ~~, location~~ and ~~parking~~Parking. Access and Parking ~~, location and parking for~~ for temporary *tents* and *membrane structures* shall be in accordance with this section.

3103.8.1 Access. Fire apparatus access roads shall be provided in accordance with Section 503.

3103.8.2 ~~Location~~Parking. ~~*Tents* or *membrane structures* shall not be located within~~ Parked vehicles or internal combustion engines shall not be located within 20 feet (6096 mm) ~~of~~ of ~~of *lot lines*, buildings, other other~~ *tents* or *membrane structures*~~, parked vehicles or internal combustion engines.~~ . For the purpose of determining required distances, support ropes and guy wires shall be considered as part of the temporary *membrane structure* or *tent*.Exception: Motor vehicle display, parking, competition, and demonstration activities in accordance with Sections 3107.15 through 3107.15.5.3.

~~**Exceptions:**~~

1. ~~Separation distance between *membrane structures* and *tents* not used for cooking is not required where the aggregate floor area does not exceed 15,000 square feet (1394 m^2).~~
2. ~~*Membrane structures* or *tents* need not be separated from buildings where all of the following conditions are met:~~
   - 2.1. ~~The aggregate floor area of the *membrane structure* or *tent* shall not exceed 10,000 square feet (929 m^2).~~
   - 2.2. ~~The aggregate floor area of the building and *membrane structure* or *tent* shall not exceed the allowable floor area including increases as indicated in the *International Building Code* .~~
   - 2.3. ~~Required *means of egress* are provided for both the building and the *membrane structure* or *tent* including travel distances.~~
   - 2.4. ~~Fire apparatus access roads are provided in accordance with Section 503.~~

Delete without substitution:

~~**3103.8.3 Location of structures in excess of 15,000 square feet in area.** *Membrane structures* having an area of 15,000 square feet (1394 m^2) or more shall be located not less than 50 feet (15 240 mm) from any other *tent* or structure as measured from the sidewall of the *tent* or *membrane structure* unless joined together by a corridor.~~

~~**3103.8.4 Membrane structures on buildings.** *Membrane structures* that are erected on buildings, balconies, decks or other structures shall be regulated as permanent *membrane structures* in accordance with Section 3102 of the *International Building Code*.~~

~~**3103.8.5 Connecting corridors.** *Tents* or *membrane structures* are allowed to be joined together by means of corridors. *Exit* doors shall be provided at each end of such corridor. On each side of such corridor and approximately opposite each other, there shall be provided~~

~~openings not less than 12 feet (3658 mm) wide.~~

3103.8.6 Fire break. An unobstructed fire break passageway or fire road not less than 12 feet (3658 mm) wide and free from guy ropes or other obstructions shall be maintained on all sides of all *tents* and *membrane structures* unless otherwise *approved* by the *fire code official*.

~~**3103.9 Structural stability and anchorage required.** *Tents* or *membrane structures* and their appurtenances shall be designed and installed to withstand the elements of weather and prevent collapsing. Documentation of structural stability shall be furnished to the *fire code official*.~~

~~**3103.9.1 Tents and membrane structures exceeding one story.** Tents and membrane structures exceeding one story shall be designed and constructed to comply with the *applicable building code*.~~

~~**3103.9.2 Tents and membrane structures greater than 7,500 square feet.** Tents and membrane structures greater than 7,500 square feet (697 m^2) shall be designed and constructed to comply with the *applicable building code*.~~

~~**3103.9.3 Tents and membrane structures with an occupant load greater than 1,000.** Tents and membrane structures with an occupant load greater than 1,000 shall be designed and constructed to comply with the *applicable building code*.~~

~~**3103.10 Temporary air-supported and air-inflated membrane structures.** Temporary air-supported and air-inflated *membrane structures* shall be in accordance with Sections 3103.10.1 through 3103.10.4.~~

3103.10.1 Door operation. During high winds exceeding 50 miles per hour (22 m/s) or in snow conditions, the use of doors in air-supported structures shall be controlled to avoid excessive air loss. Doors shall not be left open.

~~**3103.10.2 Fabric envelope design and construction.** Air-supported and air-inflated structures shall have the design and construction of the fabric envelope and the method of anchoring in accordance with ASI 77.~~

~~**3103.10.3 Blowers.** An air-supported structure used as a place of assembly shall be furnished with not less than two blowers, each of which has adequate capacity to maintain full inflation pressure with normal leakage. The design of the blower shall be so as to provide integral limiting pressure at the design pressure specified by the manufacturer.~~

~~**3103.10.4 Auxiliary inflation systems.** Places of public assembly for more than 200 persons shall be furnished with an auxiliary inflation system capable of powering a blower with the capacity to maintain full inflation pressure with normal leakage in accordance with Section 3103.10.3 for a minimum duration of 4 hours. The auxiliary inflation system shall be either a fully automatic auxiliary engine-generator set or a supplementary blower powered by an internal combustion engine that shall be automatic in operation. The system shall be capable of automatically operating the required blowers at full power within 60 seconds of a commercial power failure.~~

~~**3103.11 Seating arrangements.** Seating in *tents* or *membrane structures* shall be in accordance with Chapter 10.~~

~~**3103.12 Means of egress**. *Means of egress* for temporary *tents* and *membrane structures* shall be in accordance with Sections 3103.12.1 through 3103.12.8.~~

~~**3103.12.1 Distribution.** *Exits* shall be spaced at approximately equal intervals around the perimeter of the *tent* or *membrane structure*, and shall be located such that all points are 100 feet (30 480 mm) or less from an *exit*.~~

~~**3103.12.2 Number.** *Tents* or *membrane structures* or a usable portion thereof shall have not less than one exit and not less than the number of *exits* required by Table 3103.12.2. The total width of *means of egress* in inches (mm) shall be not less than the total *occupant load* served by a *means of egress* multiplied by 0.2 inches (5 mm) per person.~~

~~**TABLE 3103.12.2 MINIMUM NUMBER OF MEANS OF EGRESS AND MEANS OF EGRESS WIDTHS FROM TEMPORARY MEMBRANE STRUCTURES AND TENTS**~~

OCCUPANT LOAD	MINIMUM NUMBER OF MEANS OF EGRESS	MINIMUM WIDTH OF EACH MEANS OF EGRESS (inches)	MINIMUM WIDTH OF EACH MEANS OF EGRESS (inches)
		Tent	Membrane Structure
10 to 199	2	72	36
200 to 499	3	72	72
500 to 999	4	96	72
1,000 to 1,999	5	120	96
2,000 to 2,999	6	120	96
Over 3,000[a]	7	120	96

For SI: 1 inch = 25.4 mm.

a. When the occupant load exceeds 3,000, the total width of means of egress (in inches) shall be not less than the total occupant load multiplied by 0.2 inche per person.

3103.12.3 Exit openings from tents. *Exit* openings from *tents* shall remain open unless covered by a flame-resistant curtain. The curtain shall comply with the following requirements:

1. Curtains shall be free sliding on a metal support. The support shall be not less than 80 inches (2032 mm) above the floor level at the *exit*. The curtains shall be so arranged that, when open, no part of the curtains obstructs the *exit*.
2. Curtains shall be of a color, or colors, that contrasts with the color of the *tent*.

3103.12.4 Doors. *Exit* doors shall swing in the direction of *exit* travel. To avoid hazardous air and pressure loss in air-supported *membrane structures*, such doors shall be automatic closing against operating pressures. Opening force at the door edge shall not exceed 15 pounds (66 N).

3103.12.5 Aisle. The width of *aisles* without fixed seating shall be in accordance with the following:

1. In areas serving employees only, the minimum *aisle* width shall be 24 inches (610 mm) but not less than the width required by the number of employees served.
2. In public areas, smooth-surfaced, unobstructed *aisles* having a minimum width of not less than 44 inches (1118 mm) shall be provided from seating areas, and *aisles* shall be progressively increased in width to provide, at all points, not less than 1 foot (305 mm) of *aisle* width for each 50 persons served by such *aisle* at that point.

3103.12.5.1 Arrangement and maintenance. The arrangement of *aisles* shall be subject to approval by the *fire code official* and shall be maintained clear at all times during occupancy.

3103.12.6 Exit signs. *Exits* shall be clearly marked. *Exit* signs shall be installed at required *exit* doorways and where otherwise necessary to indicate clearly the direction of egress where the *exit* serves an *occupant load* of 50 or more.

3103.12.6.1 Exit sign illumination. *Exit* signs shall be either *listed* and *labeled* in accordance with UL 924 as the internally illuminated type and used in accordance with the listing or shall be externally illuminated by luminaires supplied in either of the following manners:

1. Two separate circuits, one of which shall be separate from all other circuits, for *occupant loads* of 300 or less.
2. Two separate sources of power, one of which shall be an *approved* emergency system, shall be provided where the *occupant load* exceeds 300. Emergency systems shall be supplied from storage batteries or from the on-site generator set, and the system shall be installed in accordance with NFPA 70. The emergency system provided shall have a minimum duration of 90 minutes when operated at full design demand.

~~**3103.12.7 Means of egress illumination.** *Means of egress* shall be illuminated with light having an intensity of not less than 1 foot-candle (11 lux) at floor level while the structure is occupied. Fixtures required for *means of egress* illumination shall be supplied from a separate circuit or source of power.~~

~~**3103.12.8 Maintenance of means of egress.** The required width of *exits*, *aisles* and passageways shall be maintained at all times to a *public way*. Guy wires, guy ropes and other support members shall not cross a *means of egress* at a height of less than 8 feet (2438 mm). The surface of *means of egress* shall be maintained in an *approved* manner.~~

~~SECTION 3104~~
~~TEMPORARY AND PERMANENT TENTS AND MEMBRANE STRUCTURES~~

~~**3104.1 General.** Tents and membrane structures, both temporary and permanent, shall be in accordance with this section. Permanent tents and membrane structures shall also comply with the *applicable building code*.~~

~~**3104.2 Flame propagation performance treatment.** Before a permit is granted, the owner or agent shall file a certificate executed by an *approved* testing laboratory certifying that the tents and membrane structures and their appurtenances; sidewalls, drops, and tarpaulins; floor coverings, bunting, and combustible decorative materials and effects, including sawdust where used on floors or passageways, are composed of material meeting the flame propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of NFPA 701 or shall be treated with a flame retardant in an *approved* manner and meet the flame propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of NFPA 701 , and that such flame propagation performance criteria are effective for the period specified by the permit.~~

~~**3104.3 Label.** *Membrane structures* or *tents* shall have a permanently affixed label bearing the following information:~~

1. ~~The identification of size and fabric or material.~~
2. ~~The names and addresses of the manufacturers of the *tent* or air-supported structure.~~
3. ~~A statement that the fabric or material meets the requirements of Section 3104.2.~~
4. ~~If treated, the date the fabric or material was last treated with flame-retardant solution, the trade name or kind of chemical used in treatment, name of person or firm treating the fabric or material, and name of testing agency and test standard by which the fabric or material was tested.~~
5. ~~If untreated, a statement that no treatment was applied when the fabric or material met the requirements of Section 3104.2 .~~

~~**3104.4 Certification.** An affidavit or affirmation shall be submitted to the *fire code official* and a copy retained on the premises on which the tent or air-supported structure is located. The affidavit shall attest to all of the following information relative to the flame propagation performance criteria of the fabric:~~

1. ~~Names and address of the owners of the tent or airsupported structure.~~
2. ~~Date the fabric was last treated with flame-retardant solution.~~
3. ~~Trade name or kind of *chemical* used in treatment.~~
4. ~~Name of person or firm treating the material.~~
5. ~~Name of testing agency and test standard by which the fabric was tested.~~

~~SECTION 3105~~
~~TEMPORARY SPECIAL EVENT STRUCTURES~~

~~**3105.1 General.** Operation and maintenance of temporary stage canopies shall be in accordance with Section 3104 , Sections 3105.2 through 3105.7 and ANSI E1.21 .~~

~~**3105.2 Approval.** Temporary stage canopies in excess of 400 square feet (37 m^2) shall not be erected for any purpose without first obtaining approval and a permit from the building official.~~

~~**3105.3 Permits.** Permits shall be required as set forth in Section 107.2 .~~

~~**3105.4 Use period.** Temporary special event structures erected in accordance with ANSI E1.21 shall not be erected for a period of more than six consecutive weeks.~~

~~**3105.5 Required documents.** Documents shall be submitted to the building official where required by the *USBC*.~~

~~**3105.6 Inspections.** Inspections shall comply with Section 106 and Sections 3105.6.1 and 3105.6.2 .~~

~~**3105.6.1 Independent inspector.** The owner of a temporary stage canopy shall employ a qualified, independent *approved* agency or individual to inspect the installation of a temporary stage canopy.~~

~~**3105.6.2 Inspection report.** The inspecting agency or individual shall furnish an inspection report to the building official and *fire code official*. The inspection report shall indicate that the temporary stage canopy was inspected and was or was not installed in accordance with the *approved* construction documents. Discrepancies shall be brought to the immediate attention of the installer for correction. Where any discrepancy is not corrected, it shall be brought to the attention of the building official and *fire code official* and the designated responsible party.~~

~~**3105.7 Means of egress.** The means of egress for temporary stage canopies shall comply with Chapter 10 and the *applicable building code*.~~

3105.8 Location. (Section deleted.)

~~**3105.9 Portable fire extinguishers.** Portable fire extinguishers shall be provided as required by Section 906.~~

Reason Statement:

Per SFPC Sections 101.2 through 101.4, the scope of the SFPC is maintenance and operations, not construction. Per Section 101.4 any provision that is not within the maintenance and operations scope or that conflicts with the USBC is invalid. Though a great deal of work has been done to remove invalid construction provisions from the SFPC that are in the IFC, chapter 31 has not been fully addressed. Tents are structures regulated by the USBC; therefore, all the construction related provisions of SFPC Chapter 31 for tents, special event and membrane structures are invalid provisions. This code change proposal removes the invalid construction provisions that are addressed by the USBC.

Specifically:

Chapter title- Temporary special events has been removed because the entire section is proposed to be removed since all the provisions are construction provisions addressed in the VCC. Outdoor assembly events have been added since that topic is addressed in this chapter.

3101.1- The last sentence that addresses Section 3104 is proposed for deletion as a companion to the proposal to delete that section.

3102.1- No proposed revisions.

3103.2- This section is proposed for deletion because it requires fire official approval prior to erection, which is clearly based on the IFC requirement for the fire official to regulate the erection of the tent. This is addressing the fire permit as a construction permit. Section

3103.4, which is being retained, addresses the operational permit requirement.

3103.3- No proposed revisions.

303.3.1- No proposed revisions. Already deleted per state amendment.

3103.4- No proposed revisions. This is the section that addresses operational permit requirements.

3103.5 thru 3103.6- These sections are proposed for deletion because they are construction provisions within the scope of the VCC.

3103.7- Revised to clarify that these are maintenance inspections performed per this section and the applicable building code.

3103.7.1- Revised to clarify that the reports requested documentation of the maintenance inspections performed per this section and the applicable building code.
3103.8- Location is proposed for deletion since in the context of this section it is a fire safety distance requirement within the scope of the VCC.

3103.8.1- No proposed revisions.

3103.8.2- Location is proposed for deletion since in the context of this section it is a fire safety distance requirement within the scope of the VCC. The section is proposed to be specific to maintaining separation from parked vehicles and the tent, which is within SFPC scope. Additionally, an exception is proposed to address allowances already in SFPC Section 3107.15 for vehicle parking and demonstrations within the tent.

3103.8.3 thru 3103.8.5- - These sections are proposed for deletion because they are construction provisions within the scope of the VCC.

3103.8.6- No proposed revisions.

3103.9 thru 3103.12.8 - These sections are proposed for deletion because they are construction provisions within the scope of the VCC. Section 3103.10.1 is not proposed for deletion because it is an operational requirement.

Sections 3104 and 3105- These sections are proposed for deletion in their entirety because they are construction provisions within the scope of the VCC.

Cost Impact: The code change proposal will not increase or decrease the cost

This will not affect the cost of construction since the provisions proposed for deletion are already invalid and the sections proposed for revision are editorial in nature.

FP3303.1-24

IFC: 3303.1

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2024 International Fire Code

Revise as follows:

3303.1 Program development and maintenance. ~~The~~ When required by the fire official, the *owner* or *owner's* authorized agent shall be responsible for the development, implementation and maintenance of an *approved*, written *site safety plan* establishing a fire prevention program at the project site applicable throughout all phases of the construction, repair, *alteration* or demolition work. The plan addresses the requirements of this chapter and other applicable portions of this code, the duties of staff and staff training requirements. The plan shall be submitted and *approved* before ~~a building permit is issued.~~ construction operations begin. Any changes to the plan shall be submitted for approval.

Reason Statement:

Prior to the 2021 SFPC, the owners responsibility section did not mandate approval of the plan prior to permit issuance. The 2018 was amended to state that the plan shall be available for the fire code official to review upon request. The Section in the 2021 edition was amended to mandate that the plan shall be submitted and approved prior to building permit issuance. The SFPC applies to all structures, including single family dwellings and accessory structures. The requirement for the fire safety plan applies to all construction from a simple repair to construction of a high rise. Though this is a good requirement for construction of a high rise, it is not practical for small jobs and minor repairs. I doubt any fire officials are enforcing this on every project in the jurisdiction nor are building officials holding up permit issuance until the plan is approved; but, that is the requirement. This proposal gives authority to the fire official to determine when the size and risks of the construction project warrant the need for such a comprehensive plan and does not base permit issuance on approval of the plan. This code change also contributes to regulatory reduction.

Cost Impact:

Assuming for smaller jobs the time to develop the plan takes half a day I estimate the plan development cost to be $500.00. The daily fire safety inspection is probably on average 1 hour long (will vary greatly depending on job type and size) say $100.00 an hour/day. Assuming the typical house or smaller commercial job averages 90 days for construction, this code change will save approximately $9,500.00 per project.

FP3303.1-24 Floor Modification

NOTE: the underlined text shows revisions to code change proposal FP3301-24 24 (as currently shown in cdpVA), which already incorporates changes to the 2024 IFC.

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2024 International Fire Code

Revise as follows:

3303.1 Program development and maintenance. When required by the fire official or where a fire watch is required in accordance with Section 3303.5.1, the owner or owner's authorized agent shall be responsible for the development, implementation and maintenance of an approved, written site safety plan establishing a fire prevention program at the project site applicable throughout all phases of the construction, repair, alteration or demolition work. The plan addresses the requirements of this chapter and other applicable portions of this code, the duties of staff and staff training requirements. The plan shall be submitted and approved before construction operations begin. Any changes to the plan shall be submitted for approval.

FP4106.1.3-24

SFPC: 4106.1.3 (New); IFC: SECTION 202 (New)

Proponents: Gerry Maiatico, County of Warren & Virginia Fire Prevention Association, representing Virginia Fire Prevention Association (gmaiatico@warrencountyfire.com)

2021 Virginia Statewide Fire Prevention Code

Add new text as follows:

4106.1.3 **Mobility .** Mobile food preparation vehicles shall be moveable, easily transported, or relocated without excessive effort. Mobile food preparation vehicles shall not be utilized as permanent structures by removing wheels, surrounded by decks/porches, permanently affixing to *utilities* or placing the mobile food preparation vehicle in such a manner as to prohibit the mobility of the device. Exception: Mobile food preparation vehicles that have been modified or connected to *utilities* in accordance with the applicable building code.

2024 International Fire Code

Add new text as follows:

New Definition. Utilities. The essential services that enable a building, equipment or an appliance to function effectively.

Reason Statement:
Chapter 2 of the SFPC defines the MFPV as a "vehicles, covered trailers, carts, and enclosed trailers, **or other moveable devices"**. This provides the intent that a MFPV is intended to be moveable. Localities throughout the Commonwealth have experienced the MFPV being placed in a situation where the vehicle is no longer "movable". This has been discovered as the wheels being removed, placing the vehicle up on blocks, surrounding the vehicle with decks/porches and event attaching the vehicle to a buildings electrical system or plumbing systems in a permanent in nature arrangement.

This proposal also includes a definition of *utilities*. This mirrors a proposal submitted to the termination and reconnection of a utilities system.

This proposal provides an exception where the mobile food preparation vehicle arrangement and/or connection to utilities has been permitted and inspected in accordance with the applicable building code.

Cost Impact: The code change proposal will not increase or decrease the cost
No change

PM202-24

VPMC: SECTION 202

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Property Maintenance Code

Revise as follows:

UNSAFE STRUCTURE. An existing structure determined by the code official to be dangerous to the health, safety and welfare of the occupants of the structure or the public because of, but not limited to, any of the following conditions:

1. The structure contains *unsafe equipment*;
2. The structure is so damaged, decayed, dilapidated, structurally unsafe or of such faulty construction or unstable foundation that partial or complete collapse is likely;
3. The structure is vacant and unsecured or open;
4. The degree to which the structure is in disrepair or lacks maintenance, ventilation, illumination, sanitary or heating facilities or other essential equipment;
5. The required plumbing and sanitary facilities are inoperable.

Reason Statement:

The definitions of unsafe and unfit for human occupancy were combined into the singled definition of unsafe structure during the 2021 VA code cycle. When the definitions were consolidated “vacant” was accidentally left out of the consolidated definition in item #3. This corrects that error.

Cost Impact: The code change proposal will not increase or decrease the cost

This is correcting an editorial oversight from the prior code cycle.

PM302.5-24

VPMC: 302.5

Proponents: Matthew Mertz, Fairfax County Department of Code Compliance, representing Fairfax County, Property Maintenance Official, Department of Code Compliance (matthew.mertz@fairfaxcounty.gov)

2021 Virginia Property Maintenance Code

Revise as follows:

302.5 Rodent harborage. ~~All *structures*~~ *Structures* shall be kept free from rodent harborage and *infestation*. ~~*Structures* in which rodents are found~~ Rodents found in *structures* shall be promptly exterminated by *approved* processes that will not be injurious to human health. After extermination, proper precautions shall be taken to prevent reinfestation.

Reason Statement: Continue deleting unnecessary instance of the word “All” as has been done in previous code cycles. Re-word to clarify that it’s the rodents, not the structures, that must be exterminated.

Cost Impact: The code change proposal will not increase or decrease the cost

There is no anticipated impact on costs.

PM303.2-24

VPMC: 303.2, 303.2.1 (New), 303.2.2 (New)

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Property Maintenance Code

Revise as follows:

303.2 Enclosures. Swimming pool, hot tub, and spa ~~barriers~~ enclosures shall be *maintained* in accordance with the *applicable* ~~*building code*~~*provisions of Sections 303.2.1 and 303.2.2*~~or ordinance under which such barriers were constructed.~~.

Add new text as follows:

303.2.1 Barriers. Swimming pool, hot tub and spa barriers shall be maintained in accordance with the applicable building code or ordinance under which such barriers were constructed.

303.2.2 Safety covers. Swimming pool power safety covers, and spa or hot tub lockable safety covers shall be maintained in accordance with the applicable building code under which such safety covers were installed.

Reason Statement:

This section of the VPMC was revised for Virginia prior to the addition of safety covers to the ISPSC as an acceptable means of providing enclosure for pools, spas and hot tubs. Safety cover, power safety cover, and barrier are each specifically defined in the ISPSC so safety covers are not interchangeable with barriers from a definition and code application perspective. This proposal adds safety covers to the requirements to maintain the elements of the pool enclosure.

Cost Impact: The code change proposal will increase the cost

Per Google AI- The cost of maintaining a swimming pool safety cover varies, but you can expect to spend between $150 to $200 annually for professional maintenance. Minor repairs can range from $100 to $1000.

PM309.1-24

VPMC: 309.1

Proponents: Matthew Mertz, Fairfax County Department of Code Compliance, representing representing Fairfax County, Property Maintenance Official, Department of Code Compliance (matthew.mertz@fairfaxcounty.gov)

2021 Virginia Property Maintenance Code

Revise as follows:

309.1 Infestation. ~~All *structures*~~ *Structures* shall be kept free from insect and rodent *infestation*. ~~*Structures* in which insects or rodents are found~~ Insect or rodent infestations found in *structures* shall be promptly exterminated by *approved* processes that will not be injurious to human health. After extermination, proper precautions shall be taken to prevent reinfestation.

Reason Statement: Continue deleting unnecessary instances of the word "All" as has been done in previous code cycles. Re-word to clarify that it is the infestations, not the structures, that must be exterminated.

Cost Impact: The code change proposal will not increase or decrease the cost

There is no anticipated impact on costs.

PM602.2-24

VPMC: 602.2, 602.4

Proponents: Honore Tchou, representing Myself and fellow tenants (hwt2@georgetown.edu)

2021 Virginia Property Maintenance Code

Revise as follows:

602.2 ~~Heat~~ <u>Heating and cooling</u> supply. Every *owner* and *operator* of a Group R-2 apartment *building* or other residential *building* who rents, leases, or lets one or more *dwelling unit*, rooming unit, dormitory, or guestroom on terms, either expressed or implied, to furnish ~~heat~~ <u>heating or cooling</u> to the *occupants* thereof shall supply ~~heat during the period from October 15 to May 1 to~~ <u>heating or cooling to</u> maintain a temperature of not less than ~~68°F (20°C)~~ <u>65°F (18°C) and no more than 75°F (24°C)</u> in all habitable rooms, bathrooms, and toilet ~~rooms. The *code official* may also consider modifications as provided in Section 104.5.2 when requested for unusual circumstances or may issue notice approving *building owners* to convert shared heating and cooling piping HVAC systems 14 calendar days before or after the established dates when extended periods of unusual temperatures merit modifying these dates.Exception~~<u>rooms throughout the year.</u>

> **<u>Exception</u>:** When the outdoor temperature is <u>higher than the summer design temperature or</u> below the winter outdoor design temperature for the locality, maintenance of the minimum room temperature shall not be required provided ~~that~~ the heating <u>or cooling</u> system is operating at its full design capacity. The winter outdoor design temperature for the locality shall be as indicated in Appendix D of the IPC. <u>The summer design temperature for the locality shall be as indicated in the IECC.</u>

Delete without substitution:

~~**602.4 Cooling supply.** Every *owner* and *operator* of a Group R-2 apartment *building* who rents, leases, or lets one or more *dwelling units*, rooming units, or guestrooms on terms, either expressed or implied, to furnish cooling to the *occupants* thereof shall supply cooling during the period from May 15 to October 1 to maintain a temperature of not more than 77°F (25°F) in all habitable rooms. The *code official* may also consider modifications as provided in Section 104.5.2 when requested for unusual circumstances or may issue notice approving *building owners* to convert shared heating and cooling piping HVAC systems 14 calendar days before or after the established dates when extended periods of unusual temperatures merit modifying these dates.~~

> ~~**Exceptions:** When the outdoor temperature is higher than the summer design temperature for the locality, maintenance of the room temperature shall not be required provided that the cooling system is operating at its full design capacity. The summer outdoor design temperature for the locality shall be as indicated in the IECC.~~

Reason Statement:

The reasoning for this proposal is three fold: (1) reduce ambiguities and misunderstandings in interpreting the current code, (2) align heating and cooling requirements to new realities of today's climate change, and (3) apply new scientific evidence that show the positive affects of cooler temperatures inside homes for tenant health and overall energy cost savings.

1. The proposal seeks to integrate and streamline the heating (602.2) and cooling code (602.4) while doing away with set dates to clarify and simplify the code. As currently written the code establishes two variables that create confusion for building operators and tenants. To illustrate, the heating code says, "... shall supply heat during the period from October 15 to May 1 to maintain a temperature of not less than 68F (20C) ..." This sentence creates confusion because there are two variables at play that can be at cross purposes with each other. Readers may also cherry pick the variable out of fear of being in non-compliance. For example, imagine it is April 10, and the temperature inside the building is 82F (exceedingly hot and uncomfortable). The operator may interpret the code to say that they must keep the heat on from October 15 to May 1 regardless of how hot it may be inside the building for tenants. Surely it cannot be the intention of the code to create a possible situation where operators keep running the heat regardless of whether their tenants could faint out of heat and exhaustion? And yet this is, in fact, happening in my very building where the operator refuses to turn off the heating system in April despite the temperatures being extremely elevated inside the building (see attachment - the inside of the building reached 82 while it was 74 degrees outside due to the continued use of the heating system). In addition, it is quite arbitrary that the heating system would be maintained all through April 30 at which point, at the stroke of midnight, the AC would be turned on as if the

weather transformed from winter cold to summer hot within one night. Finally, another reading of the sentence could argue that the dates should not be read as the operative part of the intent of the code in so far as it is the temperature inside the building that matters (whether it is achieve through heating, cooling, or other). If so, why not remove the dates? As such, the proposal recommends integrating the heat and cooling code and simplifying and clarifying the code by removing the dates and focusing on one variable -- the temperature range.

2. Recent weather patterns are becoming more erratic and seasons no longer adhere to traditional timetables. The current code handcuffs building operators with set dates that are no longer reflective of today's climate change. For example, the heating code says that heat must be maintained until May 1. However, as seen recently the weather turned excessively warm starting in early April, reaching over 80 degrees for many days. Yet heating continued to be deployed leading to a tremendous waste of money and gas, while making tenants uncomfortable and increasing the carbon footprint. As such, the proposal (in line with rationale 1) recommends removing the set dates to provide flexibility for operators to use either heating, cooling, or no system to maintain a general temperature range within the building of 65-75 degrees.

3. Recent scientific evidence shows that excessive heat particular at night while sleeping can be detrimental to health. See the attached files, "The Best Temperature for Sleep" and "How Your Home Temperature Can Affect Your Health." As such, this proposal recommends lowering the minimum floor to 65F degrees and the maximum ceiling to 75F for more positive health effects for tenants while also saving costs in heating bills.

If accepted, the proposal will provide flexibility for building operators to stop blindly following preset dates and be more responsive to tenants and their comfort and health based on weather forecasts and changing patterns. A plausible outcome for a building operator could be that during the winter months an operator would turn on the heating system; during shoulder season, the operator would turn off the the heating system; and during the summer months turn on the cooling system, as long as the temperature range is achieved. This way year to year variations can be taken into account by an increasingly empowered building operator freed from a preset timetable.

Cost Impact: The code change proposal will decrease the cost

I do not have statistics to back this up, but common sense would say that heating and cooling bills should go down as building operators are more empowered to turn off the heating or cooling system when it is no longer desirable.

Attached Files

- **Attachment - Excessive Heat.pdf**
  https://va.cdpaccess.com/proposal/1272/1849/files/download/923/
- **Turn off boilers.pdf**
  https://va.cdpaccess.com/proposal/1272/1849/files/download/922/
- **The Best Temperature for Sleep.pdf**
  https://va.cdpaccess.com/proposal/1272/1849/files/download/920/
- **How Your Home Temperature Can Affect Your Health.pdf**
  https://va.cdpaccess.com/proposal/1272/1849/files/download/919/

From: **Honore Tchou** hwt2@georgetown.edu
Subject: Re: Turn off boilers
Date: March 31, 2025 at 11:29 AM
To: River Place South office@riverplacesouth.com

Hi Richard and team,

Hope you're well!

I know we already discussed the Virginia building code, but I still wanted to share this pic for your awareness. The temperature in my unit is exceeding 80 degrees while the temp outside is lower. It's making river place south harder and harder to live/work in under these conditions. Thanks for listening and troubleshooting to the extent you can. I have not heard back from the housing authorities but will share if I hear anything. Thank you!

Honore

Honoré

Sent from my iPhone

> On Mar 19, 2025, at 4:01 PM, Honore Tchou <hwt2@georgetown.edu> wrote:
>
> Thanks, Richard, for the non-smoking reminder which would let me open the window more frequently. And crossing fingers that those cooler days mean cooler temps in my unit. I may need to experiment with using ice and a fan. We shall see!

Honore

On Mar 19, 2025, at 3:49 PM, River Place South <office@riverplacesouth.com> wrote:

Hi Honore,

Yes. Of course we will remind residents of our non-smoking rule.

I see that cooler temperatures are forecasted for the next 9 days.

Best,

Richard

Richard Villegas - General Manager
River Place South Housing Corporation
1011 Arlington Blvd #350
Arlington, Va. 22209
703-528-3555

From: Honore Tchou <hwt2@georgetown.edu>
Sent: Wednesday, March 19, 2025 3:30 PM
To: River Place South <office@riverplacesouth.com>
Subject: Re: Turn off boilers

Hi Richard,

Thanks again for sharing these documents. I reviewed them and see the mention of May 1. Quite fascinating that Virginia uses dates rather than temperature readings. To let you know I have emailed the Virginia Housing Division to see if there are any exceptions to the rule, and can share whatever they may say, although I don't expect much.

Which leaves me to my current predicament, that I am pretty much on my own during these shoulder seasons. With that said, can I ask you for a small favor when convenient? Can you remind folks that RPS is a non-smoking building? As I was trying to cool off yesterday with the window open, cigarette smoke would just waft through the window, another reason why it's been difficult to deal with the heat. Any help on this front is appreciated.

Thank you, Richard!

Honore

FYI: this is the temperature reading at 10:00 am in my unit (78.4) while it's 53 outside (a 25 degree difference) despite the heat turned off and shades down. Imagine when it becomes 60 or 70 outside. Hot!

<image001.jpg>

> On Mar 17, 2025, at 11:34 AM, River Place South <office@riverplacesouth.com> wrote:
>
> Hi Honore,
>
> Of course. Our pleasure.
>
> Please see link to Arlington County describing the heat requirement:
>
> https://www.google.com/url?q=https://www.arlingtonva.us/Government/Programs/Housing/Get-Help/Rental-Services/Tenant-Landlord-Rights-Responsibilities%23:~:text%3DBuilding%2520owners%2520are%2520legally%2520obligated,maintenance%2520codes%2520in%2520Arlington%2520County&source=gmail-imap&ust=1742830455000000&usg=AOvVaw1ktwqyJaL4BpcnOF0Eietq.
>
> Arlington County also provides a reference to the Virginia Uniform Statewide Building Code:
>
> https://www.google.com/url?q=https://www.dhcd.virginia.gov/virginia-uniform-statewide-building-code-usbc&source=gmail-imap&ust=1742830455000000&usg=AOvVaw1S4Ib8eiYVc2PmDNGup40K
>
> Best regards,
>
> Richard
>
> Richard Villegas - General Manager
> River Place South Housing Corporation
> 1011 Arlington Blvd #350
> Arlington, Va. 22209
> 703-528-3555
>
> -----Original Message-----
> From: Honore Tchou <hwt2@georgetown.edu>
> Sent: Monday, March 17, 2025 10:46 AM
> To: River Place South <office@riverplacesouth.com>
> Subject: Re: Turn off boilers
>
> Hi Richard,
>
> Thanks for the response, and I appreciate your acknowledgment of my past and recurring challenges with the heat at RPS, which makes it painful for me to work, rest, and sleep in my unit.
>
> I appreciate you referencing a Virginia law that requires compliance. Can you help me and clarify which Virginia law you are referencing? It would be new to me that any Virginia law directs heating or cooling of the building based on the outside temperature, but rather my understanding is that it is based on the inside temperature of the building, which is significantly higher due to insulation and ambient heat.
>
> Any assistance would be appreciated. Thank you again, Richard!
>

> Honore
>
>
>> On Mar 17, 2025, at 9:50 AM, River Place South <office@riverplacesouth.com> wrote:
>>
>> Hi Honore,
>>
>> Good morning. Hope all is well. Thank you for your email. We understand that the air flow to your convector is currently turned off which is the best we can do for the time being. If you would like us to have our team double check it, we'd be glad to.
>>
>> I believe we've explained in the past that our boilers automatically shut off when it's over 65 degrees outside. Under Virginia law we are required to maintain heat until May 1.
>>
>> As we have done in previous year, our team will continue to monitor temperatures through the month of April, but bear in mind that for example this week low temps are expected in the high 30's.
>>
>> Please le us know if you have any questions.
>>
>> Best,
>>
>> Richard
>>
>> Richard Villegas - General Manager
>> River Place South Housing Corporation
>> 1011 Arlington Blvd #350
>> Arlington, Va. 22209
>> 703-528-3555
>>
>> -----Original Message-----
>> From: Honore Tchou <hwt2@georgetown.edu>
>> Sent: Sunday, March 16, 2025 11:22 PM
>> To: River Place South Housing Corporation <riverplaceSouth@comcast.net>
>> Subject: Turn off boilers
>>
>> Hi Gail, Richard, and the River Place team,
>>
>> I hope you had a great weekend!
>>
>> Would it be possible to consider turning off the boilers? It has already become very hot in the apartment and the next two weeks will see us hitting sixties and seventies which makes the units much too hot to bear. For your info I already have the hot air turned off.
>>
>> I hope this is a reasonable request and thank you for your consideration!
>>
>> Honoré
>> 839 South
>>
>> Sent from my iPhone

From: **River Place South** office@riverplacesouth.com
Subject: RE: Turn off boilers
Date: March 17, 2025 at 9:50 AM
To: Honore Tchou hwt2@georgetown.edu

RS

Hi Honore,

Good morning. Hope all is well. Thank you for your email. We understand that the air flow to your convector is currently turned off which is the best we can do for the time being. If you would like us to have our team double check it, we'd be glad to.

I believe we've explained in the past that our boilers automatically shut off when it's over 65 degrees outside. Under Virginia law we are required to maintain heat until May 1.

As we have done in previous year, our team will continue to monitor temperatures through the month of April, but bear in mind that for example this week low temps are expected in the high 30's.

Please le us know if you have any questions.

Best,

Richard

Richard Villegas - General Manager
River Place South Housing Corporation
1011 Arlington Blvd #350
Arlington, Va. 22209
703-528-3555

-----Original Message-----
From: Honore Tchou <hwt2@georgetown.edu>
Sent: Sunday, March 16, 2025 11:22 PM
To: River Place South Housing Corporation <riverplaceSouth@comcast.net>
Subject: Turn off boilers

Hi Gail, Richard, and the River Place team,

I hope you had a great weekend!

Would it be possible to consider turning off the boilers? It has already become very hot in the apartment and the next two weeks will see us hitting sixties and seventies which makes the units much too hot to bear. For your info I already have the hot air turned off.

I hope this is a reasonable request and thank you for your consideration!

Honoré
839 South

Sent from my iPhone

November 16, 2021 / Living Healthy / Sleep

What's the Best Temperature for Sleep?

Sleeping too hot or too cold can affect a good night's rest

Which category of “sleeper” do you fall into? While some people like to keep their bedrooms cool because they “sleep hot,” others prefer to crank up the bedroom temperature because they “sleep cold.”

It can pose for an interesting debate — especially if you’re sharing a bed/bedroom with someone who doesn’t quite vibe with your sleep style. But it *is* possible to find a healthy and happy medium.

As a rule of thumb, sleep psychologist Michelle Drerup, PsyD, says to keep your bedroom at 60 to 67° F (15 to 19° C) and to think of your bedroom as your ‘cave.’ “It should be cool, dark and quiet to enhance your sleep.”

So, how exactly does temperature affect your sleep? Learn about the health implications of sleeping too hot or too cold and what your ideal sleeping temperature should be, below.

How temperature impacts sleep

We've all experienced a terrible night's sleep. We wake up the next day feeling groggy and moody, moving slowly and looking forward to the moment we can once again shut our eyes and get some rest.

There are several factors that can contribute to sleeping troubles, one being temperature.

"If your bedroom becomes uncomfortably hot or cold, you are more likely to wake up," says Dr. Drerup.

But why is this the case? One study shares that too much heat or cold exposure is directly linked to increased wakefulness and decreased rapid eye movement (REM) sleep (the stage in which one dreams). "Thermoregulation is very important for staying in restorative, slow-wave sleep stages," says Dr. Drerup. "These are the stages in which we get the most rest."

Sleeping too hot

When we sleep, our core body temperature decreases as part of the sleep initiation process, so you may crave the heat to get warm and cozy under the covers. But — if the temperature of your bedroom is too hot or humid, chances are you'll experience more restlessness and have more trouble falling/staying asleep.

"Heat is a huge disruptor for REM sleep," Dr. Drerup says. With the heat of the room, your body temperature will also rise, thus undoing the sleep initiation process entirely.

If your bedroom temperature is above 70° F, it's too hot.

Sleeping too cold

On the flip side, sleeping too cold also has its downsides. It may not affect your sleep cycles as drastically as sleeping too hot, but it may lead to other health issues.

"When we're cold, our body kicks into high gear to try and get us warm again," says Dr. Drerup. Blood vessels become constricted, breathing becomes shallow and it puts extra pressure on our cardiovascular system to get our body temperatures regulated again, she adds.

If your bedroom temperature is lower than 60° F, it's too cold.

Does ideal sleep temperature change with age?

As we age, our bodies go through many changes — one, being a decrease in body temperature and another being a decrease in melatonin (a hormone released at night associated with sleep control) and cortisol (stress hormone) levels. You may need to adjust your sleeping temperature depending on your body, but you should avoid changing it too drastically one way or the other. Talk with your doctor to see if your sleep temperature should change.

So, now that you know it's not ideal to sleep in too hot or too cold of temperatures, what *is* the best sleeping temperature? "Typically it is suggested that the optimal sleeping temperature in the bedroom for adults should be between 60 and 67° F," says Dr. Drerup. This range of temperature is thought to actually help facilitate the stability of REM sleep.

What is the ideal sleeping temperature for babies?

The best sleeping temperature for babies and toddlers is a bit higher, between 65 and 70° F.

"Sleeping on the warmer end of the ideal sleep temperature scale is more conducive for those with smaller bodies that are still developing," says Dr. Drerup. "They are not yet able to regulate their body temperature like adults can."

Keep your baby's bedroom temperature too warm though, and you run the risk of overheating. Put your child in something breathable to sleep in and try to limit the number of blankets in their crib/bed.

If you're concerned about your child being too hot while they sleep, touch the back of their neck or stomach to test your theory. If their skin is sweaty, remove a layer or decrease the temperature of the room a bit.

How to keep the ideal sleep temperature

Before you head to bed tonight, set your thermostat to the optimal sleeping temperature (60 to 67° F) and try these other tips for getting a good night's rest:

- Keep a fan in your room, so that in the case you do feel too warm, it will be easy to cool down the rest of the room.
- Avoid drinking caffeine or eating foods high in sugar (which can increase your body temperature).

- Sleep for the season, with appropriate, breathable pajamas, bed sheets and blankets.

Now it's time to put your temperature regulations to the test! If you're still experiencing sleep issues at a regulated temperature, consult with your primary doctor, who can refer you to a sleep psychologist.

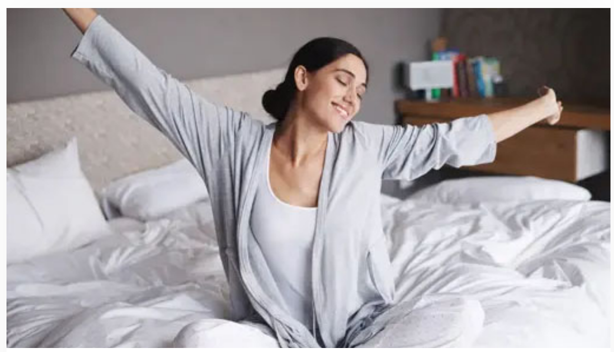
Learn more about our editorial process.

Related Articles

May 9, 2025 / Sleep

Here's How To Get More Deep Sleep and REM Sleep

Try setting a regular sleep schedule, creating a comfortable sleep environment and reducing stress



March 12, 2025 / Sleep

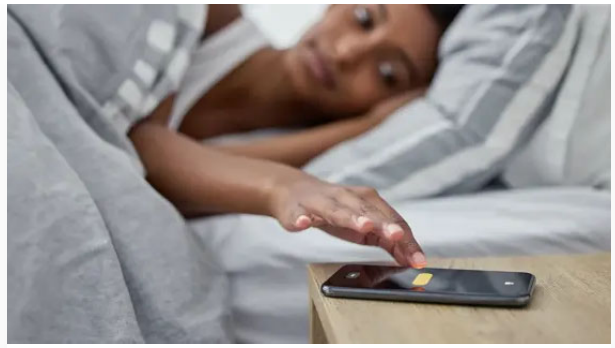
How Much Sleep Do I Really Need?

Most adults need seven to nine hours, while young children need around 10 to 14

February 12, 2025 / Parenting

4 Signs Your Child Is Ready To Stop Napping

Preschoolers who wake up early or have trouble falling asleep may not need their afternoon nap



February 11, 2025 / Sleep

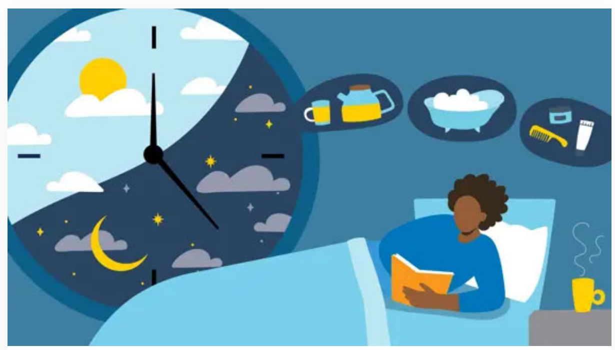
Is Snoozing Your Alarm OK?

New research may shed some light on the debated topic

January 30, 2025 / Sleep

Full Proof: Explaining How Alcohol Can Interfere With Sleep

A late-night cocktail can disrupt your sleep cycle in a way that undermines the quality of your rest



January 17, 2025 / Sleep

How To Fix Your Sleep Schedule

A regular sleep schedule is essential to your well-being — be consistent and take time to wind down

January 7, 2025 / Sleep

What's the Best Sleep Position for You?

There's no one sleep position that's best for everyone — but you may benefit from sleeping a certain way depending on your individual needs

December 24, 2024 / Sleep

Does Magnesium Help You Sleep Better?

Research is limited on whether the supplement can help you snooze, and there may be better options

Trending Topics

Sleep

Breathing Problems? Try These Sleep Positions

If you're feeling short of breath, sleep can be tough — propping yourself up or sleeping on your side may help

Mental Health

What Is Anxious Attachment Style — and Do You Have It?

If you fear the unknown or find yourself needing reassurance often, you may identify with this attachment style

Nutrition

Are Prebiotic Sodas Good for You?

If you're looking to boost your gut health, it's better to get fiber from whole foods

Health Categories to Explore

Brain & Nervous System

Children's Health

Exercise & Fitness

Heart Health

Men's Health

Mental Health

How Your Home's Temperature Can Affect Your Health

Furnace, Heating, HVAC

Did you know that the temperature of your home can significantly impact your health? Whether it's the biting chill of winter or the sweltering heat ...

Posted by Glenn | December 27, 2023

> Did you know that the temperature of your home can significantly impact your health? Whether it's the biting chill of winter or the sweltering heat of summer, finding the right balance is crucial for your well-being. Here, we explore the effects of both extremes and discuss the ideal temperature range for a healthy home.

THE GOLDILOCKS ZONE: FINDING THE PERFECT TEMPERATURE

Maintaining a comfortable temperature at home is essential for your well-being. The ideal temperature for your home depends on several factors, including your age, health, and personal preferences. During the summer months, the ideal temperature for your home is around 25.5°C (78°F). However, this temperature can vary depending on your personal preferences and the climate in your region. You can also use air conditioning, insulation, certain building materials, wall thickness, shading from direct sunlight, natural ventilation, and increased air motion (fans) to cool indoor temperatures and protect yourself against heat and heat-related illnesses.

It's important to note that an indoor temperature of less than 16°C increases the risk of

Therefore, maintaining an ideal temperature in your home is crucial for your health and comfort. The ideal temperature can vary based on personal preferences and the climate in your region, but it's recommended to set your thermostat to 20°C (68°F) during the winter months and around 25.5°C (78°F) during the summer months.

FACTORS THAT CAN AFFECT INDOOR TEMPERATURE

Maintaining a comfortable indoor temperature is essential for your health and well-being. The temperature inside your home can be affected by various factors, including:

1. Insulation

Poor insulation can lead to significant heat loss, making it difficult to maintain a comfortable temperature indoors. If your home is not well insulated, you may need to use more energy to heat or cool your home, which can increase your energy bills.

2. Building Materials

The materials used to construct your home can also affect its temperature. For instance, homes made of brick or stone tend to retain heat better than those made of wood. Additionally, the thickness of your walls can also impact your home's temperature.

3. Sunlight

Direct sunlight can significantly increase the temperature inside your home, especially during the summer months. Shading your windows or using curtains can help block out the sun's rays and keep your home cooler.

4. Airflow

Proper ventilation is crucial for maintaining a comfortable indoor temperature. Airflow can be improved by opening windows, using fans, or installing an air conditioning system. Increased air motion can also help cool indoor temperatures.

5. Outdoor Temperature

The temperature outside your home can also affect the temperature inside. During the winter months, colder temperatures outside can lead to lower indoor temperatures, while during the summer, hotter temperatures outside can cause your home to become

Maintaining the right temperature in your bedroom is crucial for a good night's sleep. According to the Sleep Foundation, the ideal temperature for sleep is between 60-68° Your body's temperature naturally drops as you sleep, so a cooler room makes it easie to fall and stay asleep.

On the flip side, sleeping in a room that is too warm or too cold can disrupt your sleep. When you are too warm, your body struggles to cool down, leading to restlessness and discomfort. According to the Cleveland Clinic, sleeping too cold can also have its downsides. When you are too cold, your body kicks into high gear to try and get you warm again, leading to restlessness and discomfort.

Being in a comfortable environment is essential for healthy sleep. Keeping your sleeping quarters at a temperature near 18.3°C (65°F), give or take a few degrees, is ideal, according to Healthline. Your body temperature naturally fluctuates throughout the night, so a slightly cooler room can help regulate your body temperature and promote restful sleep.

A good night's sleep is dependent on maintaining the right bedroom temperature. Sleeping in a room that is too warm or too cold can disrupt your sleep and lead to restlessness and discomfort. Keeping your sleeping quarters at a temperature near 18.3°C (65°F) is ideal for promoting restful sleep.

FAQs

Is it Healthier to Keep Your House Cold or Warm?

Striking the right temperature balance is like finding the Goldilocks zone for your health. While personal preferences vary, experts generally agree that maintaining a moderate temperature is key. Extreme cold or heat can strain your body, affecting everything from sleep quality to overall comfort.

What is the Healthiest Temperature to Keep in Your House?

The sweet spot for indoor temperature is typically around 20-22 degrees Celsius (68-72 degrees Fahrenheit). This range promotes better sleep, aids concentration, and supports overall physical comfort. Straying too far from this range may lead to health issues.

What are the Benefits of Living in a Cold House?

While there are benefits, it's essential to consider the downsides of a cold home. Exposure to low temperatures for extended periods can strain your cardiovascular system, potentially leading to health issues. Cold indoor environments might also contribute to discomfort and increase the risk of respiratory problems.

What Temperature is Too Cold for a House?

Experts suggest avoiding indoor temperatures below 15 degrees Celsius (60 degrees Fahrenheit) for extended periods. Prolonged exposure to colder temperatures can lead to health issues, including increased vulnerability to respiratory infections.

HOW TO KEEP CONSISTENT TEMPERATURES

Invest in a Programmable Thermostat: Installing a programmable thermostat allows you to set specific temperatures for different times of the day. This not only ensures comfort but also helps you optimize energy usage, saving on utility bills.

Seal Leaks and Insulate: Identify and seal any gaps or leaks in windows, doors, and walls. Proper insulation is key to preventing heat loss in the winter and maintaining a cool interior during the summer. Consider upgrading insulation in attics and walls for better temperature control.

Regular HVAC Maintenance: Schedule routine maintenance for your heating, ventilation, and air conditioning (HVAC) system. This includes cleaning or replacing filters, checking for leaks, and ensuring all components function efficiently. A well-maintained HVAC system contributes to consistent temperature regulation.

Use Curtains and Blinds Strategically: Curtains and blinds are more than just decorative; they play a crucial role in temperature control. Close them during the hottest parts of the day to block out sunlight and heat and open them on cooler days to let in natural warmth. Consider using thermal curtains for added insulation.

Consider Zoning Systems: Zoning systems allow you to control the temperature of different areas or rooms independently. This is particularly useful for larger homes or multi-story residences, ensuring that each space is heated or cooled according to its specific needs.

Adjustable Vent Covers: Invest in adjustable vent covers to control the airflow in each room.

strategically use accessories like curtains and fans. For personalized advice on enhancing your home's temperature control, consider reaching out to **Always Plumbing and Heating.**

STRIVE FOR BALANCE

Now you know your home's temperature plays a significant role in your overall health. Striving for a balanced and comfortable environment is essential for quality sleep, mental well-being, and immune system support.

Ready to achieve temperature stability in your home? **Contact us** for expert guidance on optimizing your HVAC system and maintaining a comfortable living space. Subscribe to our newsletter for more tips on creating a consistent and cozy home environment.

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Glenn Davis, is an industry-leading figure in the plumbing and HVAC world.

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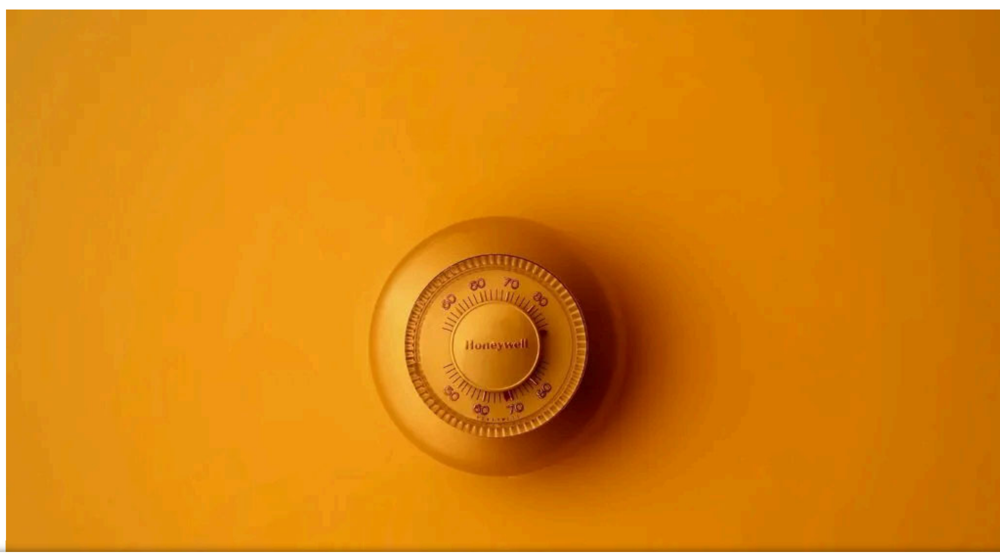

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B434-24

VCC: SECTION 202 (New), 108.1, 312.1, 434 (New)

Proponents: Michael McCabe, representing Myself (mikeamccabe@gmail.com)

2021 Virginia Construction Code

Add new text as follows:

Bomb Shelter. Bomb shelter: a structure designed to protect its occupants from explosives, fire, and weapons of mass destruction for a minimum of 30 days.
Bomb shelters must protect occupants from explosive blast effects up to 50 psi, biological agents, chemical weapons, radioactive particles, fire and smoke. Bomb shelters must have an occupancy equal to the building(s) above it, and which have access to it; they must also be capable of withstanding said building(s) collapsing upon them without any loss to the occupants' protection.
Protection Factor. A protection factor (PF) refers to the amount of exposure to a harmful substance (radioactive, chemical, biological, etc.) an individual receives, relative to how much he would receive if standing in the open.
For instance, if a bomb shelter has a PF of 40 against radioactive particles, then an individual inside the shelter would receive a dose of radiation 40 times smaller than the dose he would receive if standing in the open. This can be achieved both through the use of certain materials and through optimal designs.

Revise as follows:

108.1 When applications are required. Application for a permit shall be made to the building official and a permit shall be obtained prior to the commencement of any of the following activities, except that applications for emergency *construction*, alterations or *equipment* replacement shall be submitted by the end of the first *working day* that follows the day such work commences. In addition, the building official may authorize work to commence pending the receipt of an application or the issuance of a permit.

1. *Construction* or demolition of a *building or structure*. Installations or alterations involving (i) the removal or addition of any *wall*, partition or portion thereof, (ii) any structural component, (iii) the repair or replacement of any required component of a fire or smoke rated assembly, (iv) the alteration of any required means of egress system, including the addition or removal of *emergency supplemental hardware*, (v) water supply and distribution system, sanitary drainage system or vent system, (vi) electric wiring, (vii) fire protection system, mechanical systems, or fuel supply systems, (viii) bomb shelters, or

   (ix) any *equipment* regulated by the USBC.
2. For *change of occupancy*, application for a permit shall be made when a new certificate of occupancy is required by the VEBC .
3. Movement of a lot line that increases the hazard to or decreases the level of safety of an *existing building* or *structure* in comparison to the *building* code under which such *building* or *structure* was constructed.
4. Removal or disturbing of any asbestos containing materials during the *construction* or demolition of a *building* or *structure*, including additions.

312.1 General. Buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to the requirements of this code commensurate with the fire and life hazard incidental to their occupancy. Group U shall include, but not be limited to, the following:

Agricultural buildings

Aircraft hangars, accessory to a one- or two-family residence (see Section 412.4)

BarnsBomb Shelters

Carports

Communication equipment structures with a *gross floor area* of less than 1,500 square feet (139 m^2)

Fences more than 7 feet (2134 mm) in height

Grain silos, accessory to a residential occupancy

Livestock shelters*Marinas*

Private garages

Retaining walls

Sheds

Stables

Tanks

Towers

Add new text as follows:

434 Bomb Shelters. Bomb shelters differ from storm shelters in that they must protect the occupants from more serious hazards for a longer period of time. Bomb shelters must be constructed with a protection factor (PF) of 1000 or more. They must be well-ventilated, protect against carbon monoxide and radon poisoning, while filtering out biological, chemical, and radiological agents. They must also provide adequate water for drinking and sanitation; 30 gallons per occupant is an acceptable minimum. Adequate storage for survival supplies and repair kits for all essential systems is important. All ventilation, cooling, and sanitation systems must be operable by hand in the event of power failure, and luminescent strips can be used to guide occupants. Faraday cages shall also be included to protect occupants' electronics against electromagnetic pulses.Bomb shelters will be kept narrow; should their occupancy need to be increased, it shall be accomplished by increasing length so as to maintain roof integrity.

Reason Statement: Bomb shelters are desirable tools for saving lives in a bombing attack, whether from conventional bombs or CBRN (Chemical, Biological, Radiological, Nuclear) weapons. Attempting to build a few large, public shelters is impractical; conversely, Switzerland has successfully built bomb shelters in every new construction since the 1960s. Thus, bomb shelter standards should be oriented towards smaller, more numerous shelters that can be quickly accessed in an emergency. These should, to the greatest extend possible, also be useful in peacetime.

Cost Impact: The code change proposal will increase the cost

Locales which mandate bomb shelters will see a noticeable increase in construction costs.

Attached Files

- **Emergency Exit.pdf**
  https://va.cdpaccess.com/proposal/1280/1804/files/download/915/
- **Fire and Carbon Monoxide Protections.pdf**
  https://va.cdpaccess.com/proposal/1280/1804/files/download/914/
- **Shelter Ventilation Pump.pdf**
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- **Permanent Family Fallout Shelters.pdf**
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- **Double-action filter.pdf**
  https://va.cdpaccess.com/proposal/1280/1804/files/download/910/
- **Blast Shelters.pdf**
  https://va.cdpaccess.com/proposal/1280/1804/files/download/909/

Appendix F

Means for Providing Improved Natural Ventilation and Daylight to a Shelter with an Emergency Exit

THE NEED

Survivors in areas of heavy fallout can greatly reduce the radiation doses that they will receive, and thus decrease their risks of contracting cancer, if they sleep and spend many of their non-outdoor-working hours inside good shelters during the first several months after an attack. (See *Minimizing Excess Radiogenic Cancer Deaths After a Nuclear Attack*, by Kathy S. Gant and Conrad V. Chester, Health Physics, September 1981.)

A permanent family shelter can serve quite well for months as a post-attack temporary home if it is designed to provide adequate natural ventilation most of the time, to have adequate and easy forced ventilation by a KAP when forced ventilation is needed, and to have daylight illumination. A shelter dependent on ventilation laboriously pumped through pipes and on artificial lights even during daytime is much less practical for use as a post-attack home.

The following instructions should enable a family having an earth-covered shelter with an emergency exit to make it much more livable for months-long occupancy. The means described below for providing improved ventilation and daylight illumination also will supply guidance to survivors who will build shelters post-attack to minimize continuing radiation exposures, especially to children and pregnant women.

BUILDING AND USING A MULTI-PURPOSE EMERGENCY EXIT HOUSING

Build a multi-use emergency exit housing of the design pictured in Fig. F.1 and detailed in Fig. F.2. Size your exit housing to fit snugly over the top of your **completed** vertical exit shaft. This exit housing is made of 3/4-inch exterior plywood, four 2 x 2 x 36-inch boards, and four 16 x 16-inch window panes of 1/8-inch Plexiglas. Plated screws and waterproof adhesives are used to assure sturdiness and durability.

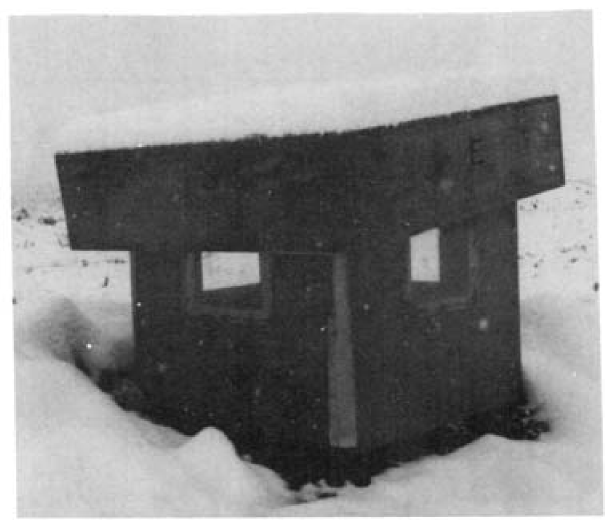


Fig. F.1. Multi-Use Emergency Exit Housing Installed Over the Square Emergency Exit Described by Figs. 17.1, 17.2, and 17.3.

The adjustable top of this exit housing measures 4 x 4 x 1 feet, and can be tilted to make different sized ventilation openings in any of four directions. The top also can be raised straight up to make various sized openings all the way around, or it can be completely closed — as explained by Fig. F.2 and the following descriptions of its uses.

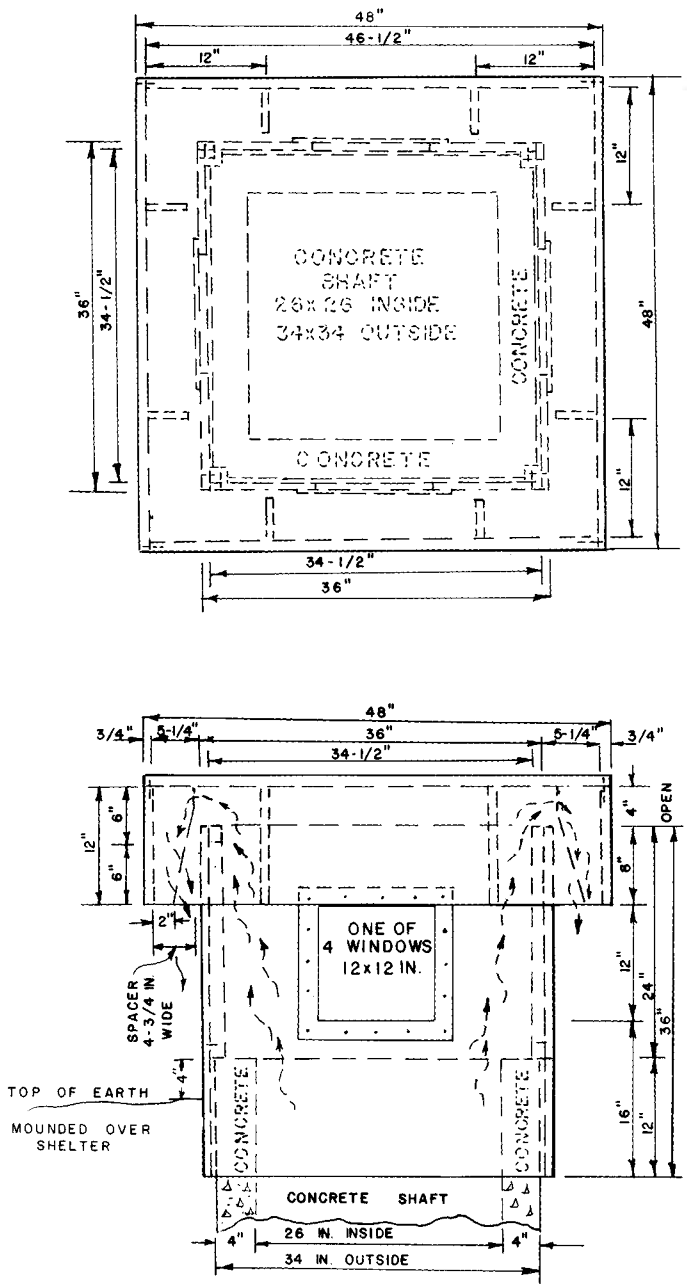


Fig. F.2. Plan and Side View of Multi-Purpose Emergency Exit Housing, on a Square Emergency Exit with 34 x 34-Inch Cross-Sectional Outside Dimensions.

Fig. F.3. The Top and Four Walls of the Multi-Purpose Emergency Exit Housing, Nested Together to Save Storage Space.

Fig. F.4. View from Below the Exit, Looking Up the Multi-Purpose Emergency Exit Housing. The top is shown supported in a tilted position by two 6-inch-wide boards placed between a wall and the top.

In Figs. F.2 and F.3, note the eight bevelled plywood guides, two on the inside of each side of the top. These guides are needed so that the top can be tilted in the position desired, merely by using a stick to raise it from below. To hold the top in a tilted or raised position, spacer boards are placed between the raised top and the upper edges of a wall or walls, as illustrated by Fig. F.4.

The illustrated housing over a vertical exit provides:

* A means to regulate shelter ventilation, and to increase natural ventilation when the wind is blowing. If, for example, the shelter's opened exit is to the north of its opened entry and a north wind is blowing, shelter airflow will blow in through the exit and out through the entry. This natural ventilating airflow, often inadequate, is increased if the adjustable top of the exit housing is not simply raised 6 inches on all four sides, but is tilted as shown in Fig. F.1, with its south side closed and its north side tilted up 6 inches to provide a 6 x 26-inch ventilation opening between the upper edge of the entry housing's north wall and its top. Then a north wind striking the north wall produces

increased air pressure over and above this wall, forcing more air into the exit and on through the shelter. In contrast, if a south wind is blowing, natural airflow will go in through the shelter's entry and out through its exit. And if the adjustable top still is tilted open to the north as illustrated, then reduced air pressure over and above the downwind north wall will "suck" an increased airflow out of the exit and through the shelter.

The measured increases in airflows through a small shelter resulting from the top of this exit housing being tilted were only 40-50 cfm when an 8-10 mph breeze was blowing. These rather small increases in airflow, however, often would make it unnecessary to supply forced ventilation to a family shelter by intermittently operating a KAP.

* Exclusion of rain, snow, and larger dust and fallout particles. The four 12 x 48-inch vertical sides of the adjustable top overhang the exit housing's walls by 6 to 12 inches. Thus the top serves as a large ventilation hood over the exit, preventing rain, snow, and larger dust and fallout particles from entering while ventilation is continuing. (To prevent entry of flies and mosquitoes, an insect screen panel, made to fit over the bottom of the emergency exit, should be kept stored in the shelter until needed. A screen door for the inner entry doorway also should be stored. Remember that installing screens greatly reduces natural ventilation airflows.)

* A reliable source of daylight. The four 12 x 12-inch windows of this exit housing let enough daylight into the exit shaft, that is painted white, to permit a person on the shelter floor below to read, even for several minutes after sunset. See Fig. F.4.

* A way to observe what is going on all around the shelter, without having to go outside, and with lessened exposure to fallout radiation.

* Quick installation post-attack, after fallout decays sufficiently. In an installation test, dirt was dug away to expose the upper 12 inches of the emergency exit shaft. Then in just 8 minutes the author and a boy carried the 5 parts of this exit housing 80 feet, positioned its four walls around the already exposed upper 12 inches of the reinforced concrete emergency exit, nailed its walls together, and placed its adjustable top in the tilted position pictured in Fig. F.1.

BUILDING AND USING AN ENTRYWAY COVER THAT PROVIDES A LARGE, PROTECTED VENTILATION OPENING

Build a shelter entryway cover that keeps out rain, snow, and the bigger dust and fallout particles while providing a large, protected ventilation opening both for natural ventilation and for easy forced ventilation by a KAP when needed. For an example of one type of entryway cover, see Fig. F.5. This photo shows a 4-piece cover, that two men in a little less than 5 minutes carried out of this shelter and installed over the 4 x 6-foot opening above the shelter's opened stairway doors.

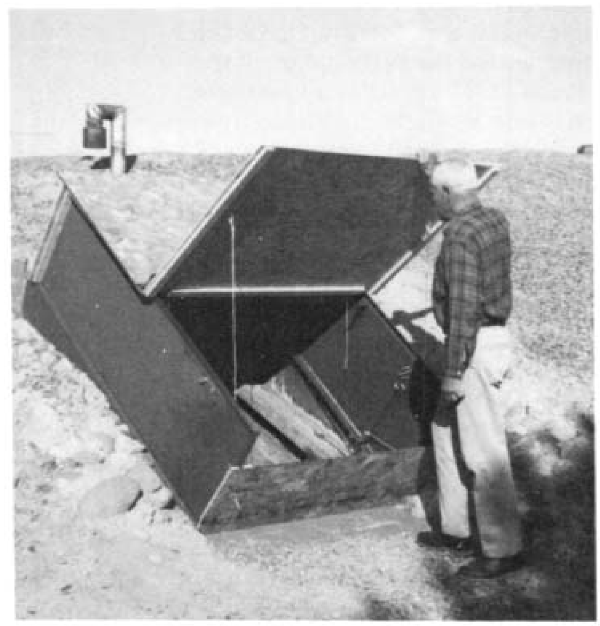
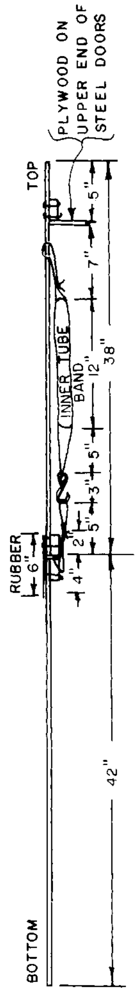


Fig. F.5. A Quickly Installable, 4-Piece Entryway Cover That Provides Easy Access and a Large, Protected Ventilation Opening.

This cover is made of 4 pieces of 1/4-inch chipboard, each 5 feet wide, and short lengths of nailed-on 1 x 2-inch boards. These 4 pieces can be tied quickly with their attached nylon cords to inner parts of the two 2 x 6-foot steel entryway doors, which are pictured in their opened, upright positions.

The lowermost of the 4 chipboard pieces has a groove near each end. The grooves are each made of 2 nailed-on lengths of 1 x 2 lumber spaced apart to fit the lower ends of the doors and hold them in their upright positions 4 feet apart. The upper edge of this lowermost piece is 8 inches below the lower raised corners of the doors, so that an 8 x 48-inch ventilation opening is assured when the lower of the two large covering pieces (pictured being held open) rests on the doors. (This step-over piece of chipboard illustrates a way to reduce the quantity of larger fallout particles that will be blown into many types of shelters, because most sandlike particles and coarse dust are blown along close to the ground. They are not blown upward and over a vertical obstruction by most winds. If an entryway has an inner, ordinary doorway, even more fallout particles can be kept out of the shelter room if an 18 x 18-inch ventilation hole is cut in the door near its top. Then air entering the shelter room will have to rise at least 4 feet above the entryway floor, and most of the larger fallout particles will be deposited on the entryway floor.)

The chipboard piece attached to the upper ends of the doors also has two 1 x 2 boards nailed near each end, forming grooves into which the upper ends of the doors fit. The doors are thus held in their upright positions and rain, etc. is kept from falling or being blown through the upper end into the entryway.



The uppermost of the two large covering pieces of chipboard (or exterior plywood) rests on the opened doors and is kept from slipping down by a 1 x 2-inch board nailed 4 inches from its upper end. This small board "hooks" over the upper edge of the piece of chipboard (or plywood) attached to the upper ends of the steel doors. (See the drawing on the side of this column.) This large piece of chipboard is securely tied to the doors.

To keep the two large pieces from moving sideways, one 1 x 2-inch board is nailed near each of their side edges, spaced so as to lie against the outside of each opened, upright steel door. To strengthen the hingeline edge of the upper large covering piece, a 1 x 2-inch board is nailed along its lower edge.

The lower of the two large covering pieces also has a reinforcing 1 x 2 nailed near its hinged edge.

The most practical hinge that the author has devised is illustrated by the drawing. This flexible hinge is much less likely to be broken than are conventional hinges, and makes it easier to build the two large covering pieces to fit over the opened doors. Note that the upper edge of the lower large piece goes under the rainproofing, 6-inch-wide rubber flap, which is nailed only along the lower edge of the upper large covering piece. Then the two large pieces are held and hinged together by first stretching each of 2 strong, 2-inch-wide rubber bands (or rustproof springs) attached by cords to the upper large covering piece, and then hooking its attached bent-wire hook onto a nylon cord loop connected to the lower large covering piece. Each strong rubber band (cut from a truck innertube) and its attached hook and nylon cords is 5 inches from an opened door. Thus hinged, the lower large piece can be easily raised to permit a person to step out of or into the stairway entry. When this hinged lower large piece is closed and tied down, a 2.7 square foot protected ventilation opening with a 10-inch overhang results.

OTHER ENTRYWAY COVERS TO PROVIDE LARGE PROTECTED OPENINGS FOR NATURAL AND KAP VENTILATION

The owner of a permanent shelter with an emergency exit may be able to improvise coverings over its entry and exit after fallout decays sufficiently to permit work outdoors — provided that he understands natural ventilation and low-pressure forced ventilation requirements, and has the boards, nails, pieces of chipboard or plywood or canvas, tools, etc. needed. But if you own a permanent shelter your pre-crisis preparations surely should include making and storing ready-to-install entryway and exit coverings of whatever designs you decide will best meet your anticipated needs for high-protection-factor sleeping and living quarters during weeks or months following a nuclear attack.

Chapter 7

Protection Against Fires and Carbon Monoxide

RELATIVE DANGERS

Fire and its consequences probably would be the third-ranking danger to unprepared Americans subjected to a massive nuclear attack. Direct blast effects would be first, covering a large fraction of densely populated areas and killing far more people. Considerably fewer fatalities seem likely to result from the second-ranking danger, fallout radiation.

THE FACTS ABOUT FIRE HAZARDS

Firestorms would endanger relatively few Americans; only the older parts of a few American cities have buildings close enough together, over a large enough area, to fuel this type of conflagration. Such fires have not occurred in cities where less than about 30% of a large area was covered with buildings.[19]

In the blast area of Hiroshima, a terrifying fire storm that burned almost all buildings within an area of about 4.4 square miles resulted from many fires being ignited almost simultaneously. Many were caused by heat radiation from the fireball. Even more fires were due to secondary effects of the blast, such as the overturning of stoves. The buildings contained much wood and other combustible materials. The whole area burned like a tremendous bonfire; strong winds that blew in from all directions replaced the huge volumes of hot air that rose skyward from the intense fires.

Lack of oxygen is not a hazard to occupants of shelters in or near burning buildings or to those in shelters that are closed tightly to prevent the entry of smoke or fallout. Carbon monoxide, toxic smoke from fires, or high concentrations of carbon dioxide from shelter occupants' exhaled breaths would kill occupants before they suffered seriously from lack of oxygen.

FIRES IGNITED BY HEAT RADIATION

Figure 7.1 shows a wood-frame house after it was heated for one second by heat radiation from a small nuclear weapon exploded in a Nevada test. This test house had no furnishings, but the heat was intense enough to have ignited exposed upholstery, curtains, bedding, papers, etc. in a typical home.

Heat radiation will set fire to easily ignitable materials (dry newspapers, thin dark fabrics, dry leaves and dry grass) in about the same extensive areas over which blast causes moderate damage to frame houses. The blast wave and high-speed blast winds will blow out many flames. However, tests have shown that fire will continue to smolder within some materials such as upholstery and dry rotted wood, and after a while it often will burst into flame and will spread. The burning automobile pictured in Fig. 7.2 is an example of such ignition beyond the range of severe blast damage.

The number of fires started by heat radiation in areas where blast is not severe can be reduced by whitewashing the insides of window panes and by removing flammable materials from places in and around houses where heat radiation could reach them. Also, occupants of shelters in some homes that would be only slightly damaged by blast could move quickly to extinguish small fires and throw out smoldering upholstered articles before fallout is deposited.

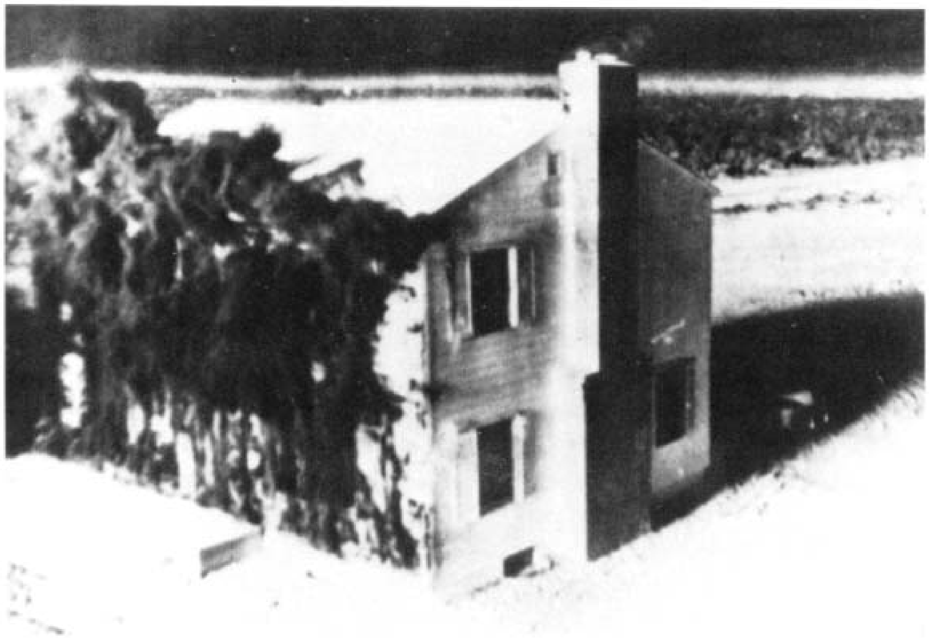


Fig. 7.1. Heat radiation charred the paint on this house, which had been painted white to reflect heat rays. The charring instantaneously produced the smoke. However, precautions had been taken to prevent this typical U.S. house from being destroyed by fire, because the test was made to enable engineers to study the effects of blast, rather than fire. The house was demolished by the 5-psi overpressure blast that struck seconds later, but it did not burn.

Fig. 7.2. Thermal radiation from a nuclear explosion entered the car above through its closed windows and ignited the upholstery. The windows were blown out by the blast a few seconds later. However, the explosion was at such a distance that the blast wave was not severe enough to dent the car body.

Earth-covered shelters can be protected against heat radiation from nuclear explosions and other causes by painting any exposed wood and other combustible materials at shelter openings with a thick coating of slaked lime (old-fashioned white-wash). The World War II firebombing of Kassel was less effective than were similar raids on other German cities because the roof timbers of buildings had been so treated.[20]

Figure 7.3 illustrates the effectiveness of a thick coating of slaked lime in protecting a rough pine board against ignition by heat radiation. No flames from the burning logs touched the board. (Before this photograph was taken, the uppermost burning logs of a vertical-sided pile were removed so that the board could be seen clearly.)

Chinese civil defense instructions recommend coating exposed wood with both slaked lime and mud.[21] If only mud is available, a coating of it protects wood quite well. If kept damp, a mud coating is even more effective. (Simply keeping all exposed flammable materials damp is helpful.)

In blast areas, cloth or plastic canopies over the openings of expedient shelters usually would be ignited by the heat and certainly would be blown away by even moderate blast winds. If extra canopies and stakes could be made and kept inside the shelter, these replacements could be quickly erected after blast winds subside and before fallout begins—at least 15 minutes after the explosion. If no spare canopies were available, it would be best to keep the available canopies and their stakes inside the shelter, if it were not raining.

FOREST AND BRUSH FIRES

Unless forests or brushy areas are dry, it is difficult to start even scattered fires. Dangerous mass fires would be unlikely, except in blast areas where the heat radiation would be very intense. However, people building a shelter would do well to select a shelter site at least as far away from trees as the height of the tallest tree that could fall on the shelter—because of fire and smoke hazards in dry weather, and because digging a shelter among tree roots is difficult.

Fig. 7.3. Heat radiation had ignited the flaming half of the board on the ground, while the half near the shovel—painted white with a thick coating of slaked lime—had not even begun to smoke.

CAUSES OF FIRE

Figure 7.4 pictures the same house shown in Fig. 7.1 after it had been struck by the blast effects of a small nuclear test explosion at the 5-psi overpressure range. (If the house had been hit by the blast effects of a multimegaton weapon, with longer-lasting blast winds, it would have been wrecked about as completely at the 3-psi overpressure range. At the 3-psi overpressure range, the blast winds from an explosion 1000 times as powerful as the Nevada test explosion that wrecked this house would blow 10 times as long. This longer-duration, 100-mph blast wind would increase the damage done by the blast wave. The 3-psi overpressure range from a 20-megaton surface burst is about 10 miles from the center of the crater, and from a one-megaton surface burst, about 4 miles.[6])

If the blast-wrecked house shown in the illustration had had a furnace in operation when it was demolished, the chances of its being set on fire would have been high. In Hiroshima many of the first fires resulted from secondary effects of blast, especially the overturning of stoves, and not from heat radiation. Although the air burst produced no fallout, firefighters from undamaged, nearby communities were unable to reach most of the burning areas because of blast debris blocking the roads. Later they were kept from burning areas by the intense heat. Some water mains were broken, which made water unavailable for firefighting in certain areas.

In the event of an attack on the United States employing many surface bursts, fallout would prevent firefighting for days to weeks in a large part of the most populated regions.

The basements of many substantial buildings will withstand 5-psi blast effects and can prevent occupants from suffering serious injuries from blast. Most home basements can be reinforced with stout boards and posts so as to give good protection against blast effects up to considerably higher than 5 psi. But considering the dangers of fires in probable blast areas, it is safer to build an earth-covered shelter well removed from buildings than it is to seek protection in shelters inside buildings.

CARBON MONOXIDE AND TOXIC SMOKE

If an undamaged building is burning, people inside may be killed by carbon monoxide, toxic smoke, or fiery-hot air. Tests have shown that even fast-burning, rubble-free fires produce very high concentrations of carbon monoxide. If large-scale fires are burning near a shelter, the dangers from both carbon dioxide and carbon monoxide may continue for as long as 1½ hours after ignition.[22] Therefore, the ventilation pipes or openings of a shelter should not be placed close to a building that might be expected to burn.

In the smoldering rubble of a large test fire, after 24 hours the carbon monoxide concentration was still more than 1% and the air temperature was

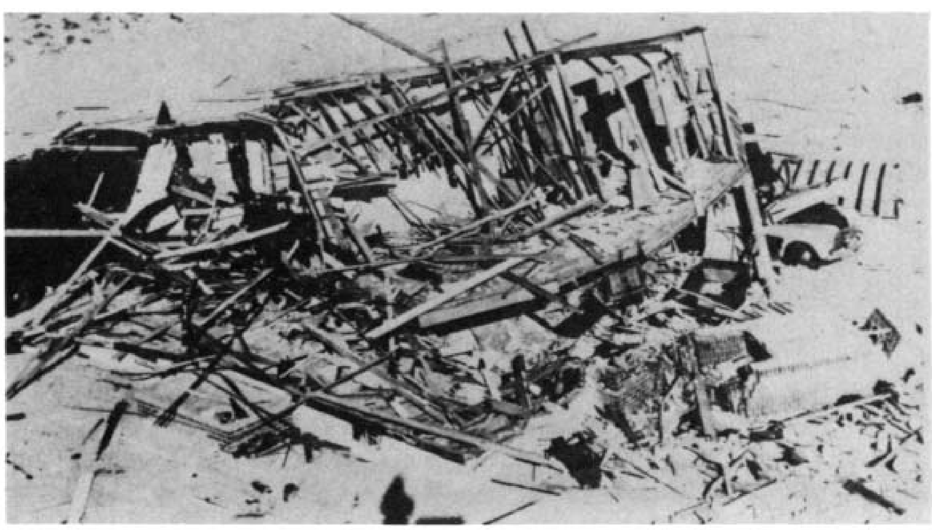


Fig. 7.4. Unburned wreckage of the same two-story, wood-frame house pictured in Fig. 7.1 after being wrecked by the 5-psi blast effects of a small nuclear test explosion.

1900°F. A carbon monoxide concentration of only 0.08% (8 parts CO in 10,000 parts of air) will cause headache, dizziness, and nausea in 45 minutes, and total collapse in 2 hours.

Realization of carbon monoxide dangers to persons in simple fallout shelters and basements may have led the writers of Soviet civil defense publications to define the "zone of total destruction" as the blast areas where the overpressure exceeds 7 psi and "residential and industrial buildings are completely destroyed ... the rubble is scattered and covers the burning structures," and "As a result the rubble only smolders, and fires as such do not occur."[23] Smoldering fires produce more carbon monoxide than do fiercely burning fires. Whether or not the occupants of basement shelters survive the direct blast effects is of little practical importance in those blast areas where the rubble overhead burns or smolders. So in the "zone of complete destruction," Russian rescue brigades plan to concentrate on saving persons trapped inside excellent blast shelters by the rubble.

About 135,000 Germans lost their lives in the tragic city of Dresden during three days of firebomb raids. Most casualties were caused by the inhalation of hot gases and by carbon monoxide and smoke poisoning.[20] Germans learned that when these dangers were threatening an air raid shelter, the occupants' best chance of survival was to run outside, even if the bombs were still falling. But in a nuclear war the fallout dose rate may be so high that the occupants of a shelter threatened by smoke and carbon monoxide might suffer a more certain and worse death by going outside. Instead, if they know from instrument readings and their calculations that they probably would receive a fatal dose before they could reach another shelter, the occupants should close all openings as tightly as possible. With luck, carbon monoxide in deadly concentrations would not reach them, nor would they be overcome by heat or their own respiratory carbon dioxide before the fire dangers ended.

Dr. A. Broido, a leading experimenter with fires and their associated dangers, reached this conclusion: "If I were building a fallout shelter I would spend a few extra dollars to build it in my backyard rather than in my basement, locating the intake vent as far as possible from any combustible material. In such a shelter I would expect to survive anything except the close-in blast effects."[22]

This advice also applies to expedient shelters built during a crisis.

Appendix B
How to Make and Use a Homemade Shelter-Ventilating Pump, the KAP

I. THE NEED FOR SHELTER AIR PUMPS

In warm weather, large volumes of outside air MUST be pumped through most fallout or blast shelters if they are crowded and occupied for a day or more. Otherwise, the shelter occupants' body heat and water vapor will raise the temperature-humidity conditions to DANGEROUSLY high levels. If adequate volumes of outdoor air are pumped through typical belowground shelters in hot weather, many times the number of persons could survive the heat than otherwise could survive in these same shelters without adequate forced ventilation. Even in cold weather, about 3 cubic feet per minute (3 cfm) of outdoor air usually should be pumped through shelters, primarily to keep the carbon dioxide exhaled by shelter occupants from rising to harmful concentrations.

The KAP (Kearny Air Pump) is a practical, do-it-yourself device for pumping adequate volumes of cooling air through shelters—with minimum work. The following instructions have been improved repeatedly after being used by dozens of small groups to build KAPs—including families, pairs of housewives, and children. None of these inexpert builders had previously heard of this kind of pump, yet almost all groups succeeded in making one in less than 4 hours after assembling the materials. Their successes prove that almost anyone, if given these detailed and thoroughly tested instructions, can build a serviceable, large-volume air pump of this simple type, using only materials and tools found in most American homes.

If possible, build a KAP large enough to pump through your shelter at least 40 cubic feet per minute (40 cfm) of outdoor air for each shelter occupant. If 40 cfm of outdoor air is pumped through a shelter and distributed within it as specified below, even under heat-wave conditions the effective temperature of the shelter air will not be more than 2°F higher than the effective temperature outdoors. (The effective temperature is a measure of air's effects on people due to its heat, humidity, and velocity.) The 36-inch-high by 29-inch-wide KAP described in these instructions, if used as specified, will pump at least 1000 cfm of outside air through a shelter that has the airflow characteristics outlined in these instructions.

If more than 25 persons might be expected to occupy a shelter during hot weather, then it is advisable to build a larger KAP. The 72-inch-high by 29-inch-wide model described can pump between 4000 and 5000 cfm.

To maintain tolerable temperature-humidity conditions for people in your shelter during hot weather, you **must**:

- Pump enough outdoor air all the way through the shelter (40 cfm for each occupant in very hot, humid weather).
- Distribute the air evenly within the shelter. If the KAP that pumps air through the shelter does not create air movement that can be felt in all parts of the shelter in hot weather, one or more additional KAPs will be needed to circulate the air and gently fan the occupants.
- Encourage the shelter occupants to wear as little clothing as practical when they are hot. (Sweat evaporates and cools best on bare skin.)

- Supply the occupants with adequate water and salt. For prolonged shelter occupancy under heat-wave conditions in a hot part of the country, about 4 quarts of drinking water and 1/3 ounce (1 tablespoon) of salt per person are required every 24 hours, including salt in food that is eaten. Normal American meals supply about 1/4 ounce of salt daily. Salt taken in addition to that in food should be dissolved in the drinking water.

- Pump outdoor air through your shelter day and night in warm weather, so that both the occupants and the shelter are cooled off at night.

Almost all of the danger from fallout is caused by radiation from visible fallout particles of heavy, sand-like or flakey material. The air does **not** become radioactive due to the radiation continuously given off by fallout particles.

The visible fallout particles rapidly "fall out" of slow moving air. The air that a KAP pumps through a shelter moves at a low speed and could carry into the shelter only a very small fraction of the fallout particles that cause the radiation hazard outside. This fraction, usually not dangerous, can be further reduced if occupants take the simple precautions described in these instructions.

CAUTION

Before anyone starts to build this unusual type of air pump, ALL WORKERS SHOULD READ THESE INSTRUCTIONS AT LEAST UP TO **SECTION V, INSTALLATION.** Otherwise, mistakes may be made and work may be divided inefficiently.

When getting ready to build this pump, all workers should spend the first half-hour studying these instructions and getting organized. Then, after materials are assembled, two inexperienced persons working together should be able to complete the 3-foot model described in the following pages in less than 4 hours. To speed up completion, divide the work; for example, one person can start making the flaps while another begins work on the pump frame.

II. HOW A KAP WORKS

As can be seen in Figs. 1 and 2, a KAP operates by being swung like a pendulum. It is hinged at the top of its swinging frame. When this air pump is pulled by a cord as illustrated, its flaps are closed by air pressure and it pushes air in front of it and "sucks"

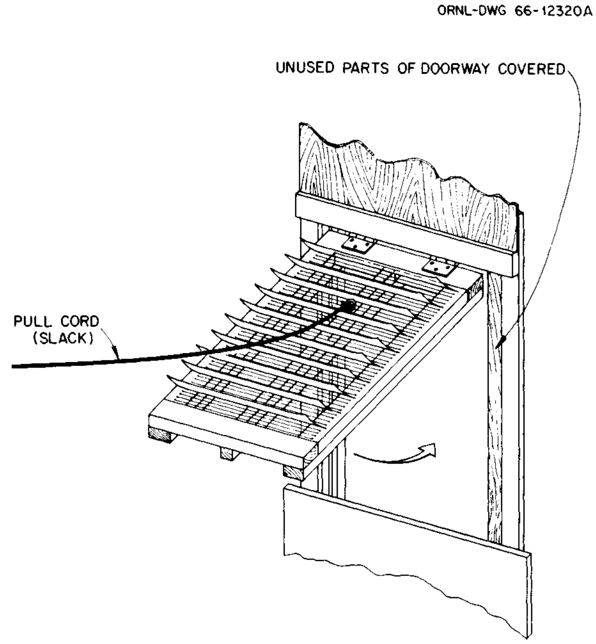


Fig. 1. Section through the upper part of a doorway, showing operation of a KAP.

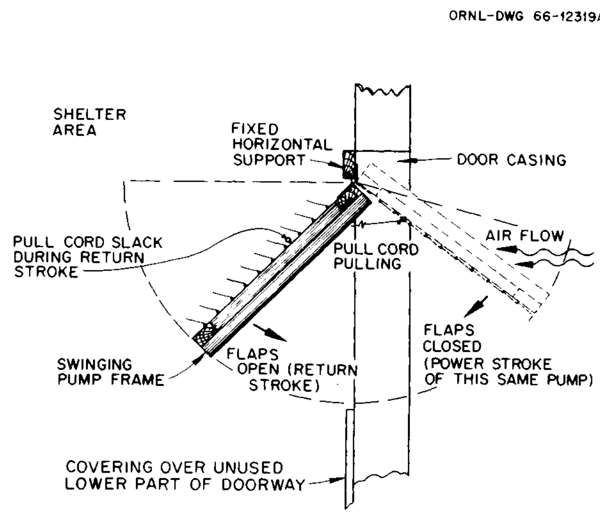


Fig. 2. KAP in doorway (with flaps open during its return stroke).

air in back of it. Thus a KAP pumps air through the opening in which it swings. This is the power stroke. During its power stroke, the pump's flaps are closed against its flap-stop wires or strings, which are fastened across the face of the frame.

When a KAP swings freely back as a pendulum on its return stroke, all its flaps are opened by air pressure. The pumped air stream continues to flow in the direction in which it has been accelerated by the power stroke, while the pump itself swings in the opposite direction (see Fig. 2). Thus the flaps are one-way valves that operate to force air to flow in one direction, where desired.

The KAP can be used: (1) to supply **outdoor** air to a shelter, (2) to distribute air within a shelter, and/or to fan the occupants.

1. To force **outdoor** air **through** a shelter, an **air-supply** KAP usually is operated as an air-intake pump by pulling it with a cord (see Fig. 1). (Only rarely is it necessary to operate a KAP as an air-exhaust pump by pushing it with a pole, as described in the last section of these instructions.)

2. To distribute air **within** a shelter and/or to fan the occupants, **air-distribution** KAPs may be hung overhead and operated as described later.

III. INSTRUCTIONS FOR BUILDING A KAP

In this section, instructions are given for making a KAP 36 inches high and 29 inches wide, to operate efficiently when swinging in a typical home basement doorway 30 inches wide. If your doorway or other ventilation opening is narrower or wider than 30 inches, you should make your KAP 1 inch narrower than the narrowest opening in which you plan to install it. Regardless of the size of the KAP you plan to build, first study the instructions for making the 36 × 29-inch model.

In Section VII you will find brief instructions for making a narrower and even simpler KAP, one more suitable for the narrow openings of small trench shelters and other small expedient shelters. Section VIII covers large KAPs, for large shelters.

A. Materials Needed for a KAP 36 inches High by 29 inches Wide

The preferred material is listed as first (1st) choice, and the less-preferred materials are listed as (2nd), (3rd), and (4th) choices. It is best to assemble, spread out, and check all your materials before beginning to build.

1. The pump frame and its fixed support:

- Boards for the frame:

(1st) 22 ft of 1 × 2-in. boards. (A nominal 1 × 2-in. board actually measures about 3/4 × 1-3/4 in., but the usual, nominal dimensions will be given throughout these instructions.) Also, 6 ft of 1 × 1-in. boards. Soft wood is better.

(2nd) Boards of the same length that have approximately the same dimensions as 1 × 2-in. and 1 × 1-in. lumber.

(3rd) Straight sticks or metal strips that can be cut and fitted to make a flat-faced KAP frame.

- Hinges: (1st) Door or cabinet butt-hinges; (2nd) metal strap-hinges; (3rd) improvised hinges made of leather, woven straps, cords, or 4 eyescrews which can be joined to make 2 hinges. (Screws are best for attaching hinges. If nails are used, they should go through the board and their ends should be bent over and clinched—flattened against the surface of the board.)

- A board for the fixed horizontal support: (1st) A 1 × 4-in. board that is at least 1 ft longer than the width of the opening in which you plan to swing your pump; (2nd) A wider board.

- Small nails (at least 24): (1st) No. 6 box nails, about 1/2 in. longer than the thickness of the two boards, so their pointed ends can be bent over and clinched); (2nd) other small nails.

2. The flaps (See Figs. 1, 2, 6, 7, and 8):

- Plastic film or other **very light,** flexible material—12 square feet in pieces that can be cut into 9 rectangular strips, each 30 × 5 1/2 in.: (1st) polyethylene film 3 or 4 mils thick (3 or 4 one-thousandths of an inch); (2nd) 2-mil polyethylene from large trash bags; (3rd) tough paper.

- Pressure-sensitive waterproof tape, enough to make 30 ft of tape 3/4 in. to 1 in. wide, for securing the hem-tunnels of the flaps: (1st) cloth duct tape (silver tape); (2nd) glass tape; (3rd) scotch tape; (4th) freezer or masking tape, or sew the hem tunnels. (Do not use a tape that stretches: it may shrink afterward and cause the flaps to wrinkle.)

3. The flap pivot-wires:

(1st) 30 ft of smooth wire at least as heavy and springy as coat hanger wire, that can be made into **very straight** pieces each 29 in. long (nine all-wire coat hangers will supply enough); (2nd) 35 ft of somewhat thinner wire, including light, flexible insulated wire; (3rd) 35 ft of smooth string, preferably nylon string about the diameter of coat hanger wire.

4. The pull cord:

(1st) At least 10 ft of cord; (2nd) strong string; (3rd) flexible, light wire.

5. The flap-stops:

- (1st) 150 ft of light string; (2nd) 150 ft of light, smooth wire; (3rd) 150 ft of very strong thread; (4th) 600 ft of ordinary thread, to provide 4 threads for each stop-flap.
- (lst) 90 tacks (not thumbtacks); (2nd) 90 small nails. (Tacks or nails are desirable but not essential, since the flap-stops can be tied to the frame.)

B. Tools

A hammer, saw, wirecutter pliers, screwdriver, scissors, knife, yardstick, and pencil are desirable. However, only a strong, sharp knife is essential for making some models.

C. Building a KAP 36 inches High by 29 inches Wide

A 36×29-in. KAP is most effective if operated in an air-intake or exhaust opening about 40 in. high and 30 in. wide. (If your shelter might have more than 25 occupants in hot weather, read all these instructions so you will understand how to build a larger pump, briefly described in Section VIII.)

NOTE THAT THE WIDTHS AND THICKNESSES OF ALL FRAME PIECES ARE EXAGGERATED IN ALL ILLUSTRATIONS.

1. The frame

a. Cut two pieces of 1 × 2-in. boards, each 36 in. long, and two pieces of 1 × 2-in. boards, each 29 in. long; then nail them together(see Fig. 3). Use nails that do not split the wood, preferably long enough to go through the boards and stick out about 1/2 in. on the other side. (To nail in this manner, first put blocks under the frame so that the nail points will not strike the floor.) Bend over nail points which go through.

Next, cut and nail to the frame a piece of 1 × 1-in. lumber 36 in. long, for a center vertical brace. (If you lack time to make or to find a 1 × 1-in. board, use a 1 × 2-in. board.) Figure 3 shows the back side of the frame; the flap valves will be attached on the front (the opposite) side.

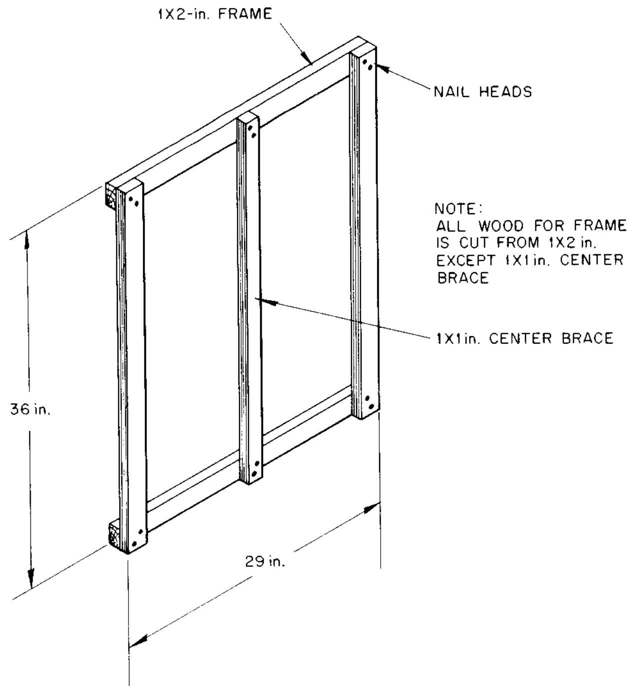


Fig. 3. KAP frame (looking at the back side of the frame).

b. To make the front side smooth and flat so that the flaps will close tightly, fill in the spaces as follows: Cut two pieces of 1 × 2-in. boards long enough to fill in the spaces on top of the 36-in. sides of the frame between the top and bottom horizontal boards, and nail these filler boards in place. Do the same thing with a 1 × 1-in. board (or a board the size of that used for the center brace) as a filler board for the center brace (see Fig. 4).

If the frame is made of only one thickness of board 3/4 in. to 1 in. thick, it will not be sufficiently heavy to swing back far enough on its free-swinging return stroke.

2. The hinges

Ordinary door butt-hinges are best. So that the pump can swing past the horizontal position, the hinges should be screwed onto the front of the frame, at its top, in the positions shown in Fig. 4. (Pick one of the 29-in. boards and call it the top.) If you do not have a drill for drilling a screw hole, you can make a hole by driving a nail and then pulling it out. Screw the screw into the nail hole.

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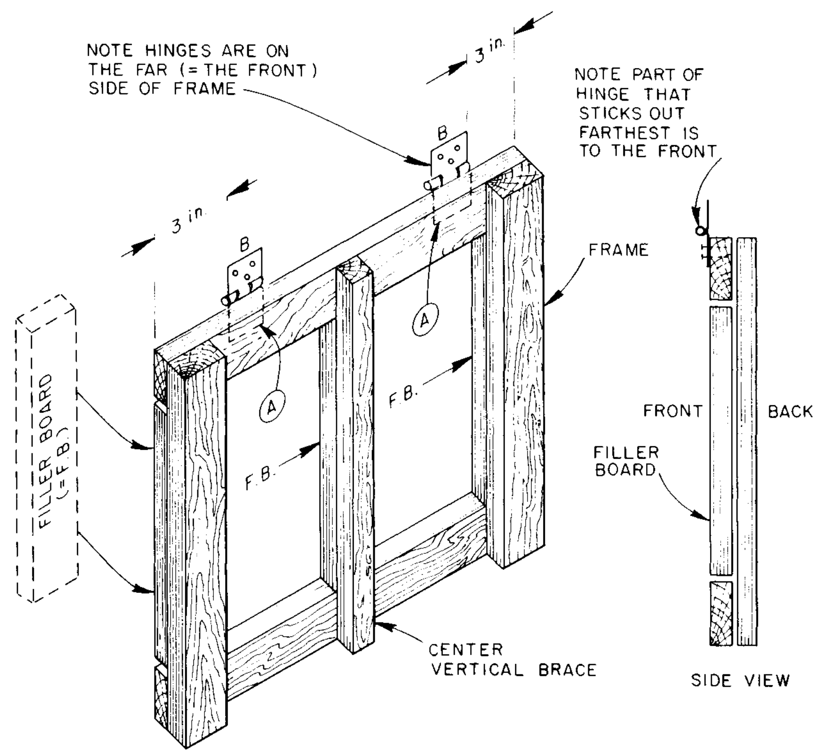

Fig. 4. Completing the frame.

3. The pivot-wires and flaps

a. Make 9 flap pivot-wires. If you have smooth, straight wire as springy and thick as coat hanger wire, use it to make **nine** 29-in.-long straight lengths of wire. If not, use wire from all-wire coat hangers or use strings. First, cut off all of the hook portion of each coat hanger, including the twisted part. If you have only ordinary pliers, use the cutter to "bite" the wire all around; it will break at this point if bent there. Next, **straighten** each wire **carefully**. Straighten all the bends so that each wire is straight within $^1/_4$ in., as compared to a straight line. Proper straightening takes 1 to 5 minutes per wire. To straighten, repeatedly grasp the bent part of the wire with pliers in slightly different spots, each time bending the wire a little with your other hand. Then cut each wire to a 29-in. length. Finally, bend no more than $^1/_2$ in. of each end at a right angle and in the same plane—that is, in directions so that all parts of the bent wire will lie flat against a smooth surface. The bent ends are for secure attachment later (see Fig. 8).

b. Make 9 polyethylene flaps that will be the hinged valves of the KAP. First cut 9 strips, making each strip 30 in. long by $5^1/_2$-in. wide (see Fig. 5). To cut plastic flaps quickly and accurately, cut a long strip of plastic 30 in. wide. Then cut off a flap in this way: (1) draw a cutting guideline on a wide board $5^1/_2$ in. from an edge; (2) place the 30-in.-wide plastic strip so that it lies on this board, with one of the strip's side edges just reaching the edge of the board; (3) place a second board over

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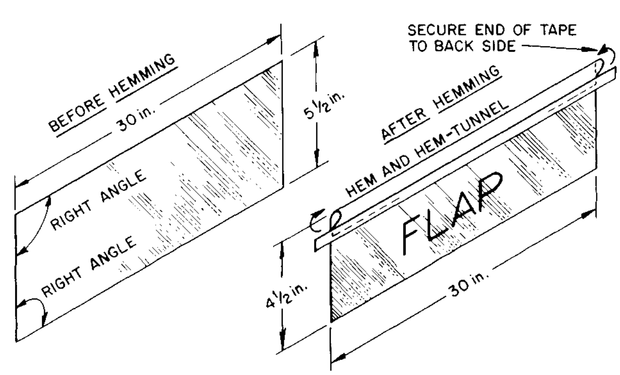

Fig. 5.

the plastic on the first board, with a straight edge of this second upper board over the guideline on the lower board; and finally (4) cut off a flap by running a **sharp** knife along the straight edge of the upper board.

To form a hem along one of the 30-in. sides of a $5\frac{1}{2} \times 30$-in. rectangular strip, fold in a **1-in.** hem. This makes the finished flap $4\frac{1}{2}$ in. wide.

To hold the folded hem while taping it, paper clips or another pair of hands are helpful. For each hem, use two pieces of pressure-sensitive tape, each about 1 in. wide and 16 in. long. Or make the hem by sewing it very close to the cut edge to form a hem-tunnel (see Fig. 5).

After the hem has been made, cut a notch with scissors in each hemmed corner of the flap (Figs. 6 and 8). Avoid cutting the tape holding the hem. Each notch should extend downward about $\frac{1}{2}$ in. and should extend horizontally from the outer edge of the flap to $\frac{1}{4}$ in. inside the inner side of the frame, when the flap is positioned on the frames as shown in Fig. 6.

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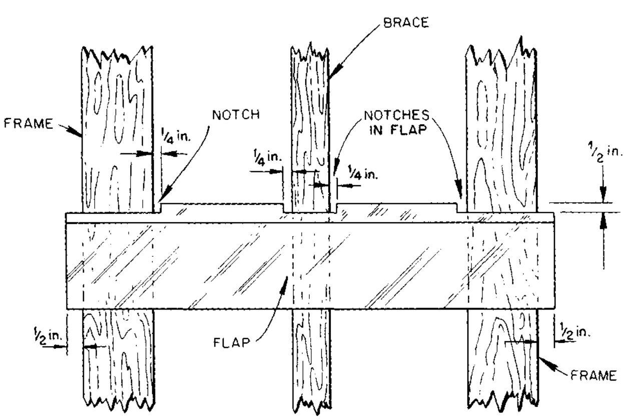

Fig. 6. Sizes of notches in flaps.

Also cut a notch in the center of the flap (along the hem line) extending $\frac{1}{2}$ in. downward and extending horizontally $\frac{1}{4}$ in. beyond each of the two sides of the vertical brace (see Fig. 6). The notch MUST be wider than the brace. [However, if you are building a pump using wire netting for flap-stops (see Fig. 13), then do NOT cut a notch in the center of each flap.]

c. Take the 9 pieces of straightened wire and insert one of them into and through the hem-tunnel of each flap, like a curtain rod running through the hem of a curtain. Check to see that each flap **swings freely** on its pivot-wire, as illustrated by Fig. 7. Also see Fig. 8.

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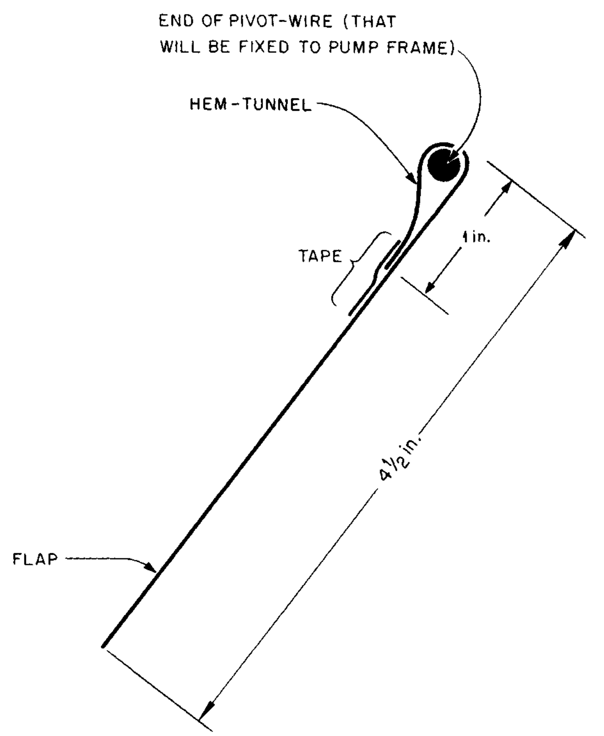

Fig. 7. End view.

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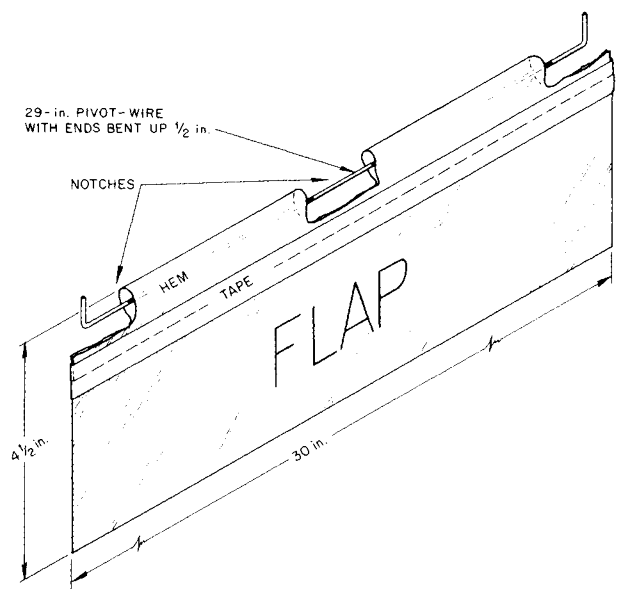


Fig. 8.

d. Put aside the flaps and their pivot-wires for use after you have attached the flap-stops and the hinges to the frame, as described below.

e. Using the ruler printed on the edge of this page, mark the positions of each pivot-wire (the arrowheads numbered 0, $3^5/_8$, $7^1/_4$ in.) and the position of each flap-stop (the four marks between each pair of numbered arrowheads on this ruler). All of these positions should be marked both on the vertical sides of the 36-in.-long boards of the frame and on the vertical brace. Mark the position of the uppermost pivot-wire (the "0" arrowhead on this ruler) $^1/_4$ in. below the top board to which the hinges have been attached (see Figs. 9 and 10).

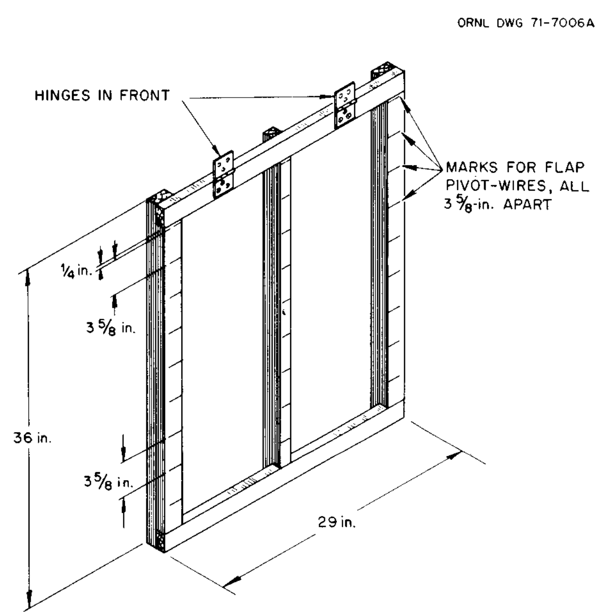


Fig. 9.

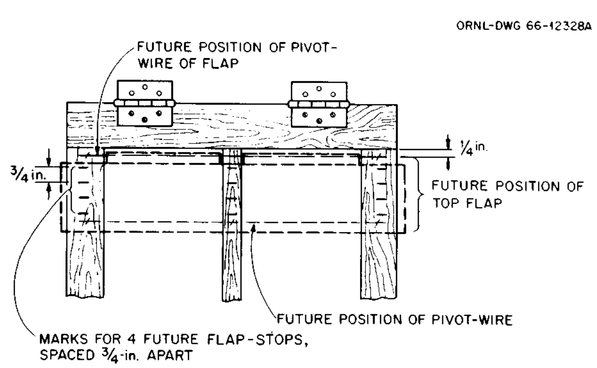


Fig. 10.

4. The flap-stops

So that the flaps may swing open on only one side of the frame (on its front, or face), you must attach horizontal flap-stops made of strings or wires across the face of the frame. (See Figs. 10 and 11.) Nail or tie four of these flap-stops between the marked points where each pair of the horizontal pivot-wires for the flaps will be placed. Be careful not to connect any flap-stops in such a way that they cross the horizontal open spaces in which you later will attach the flap pivot-wires.

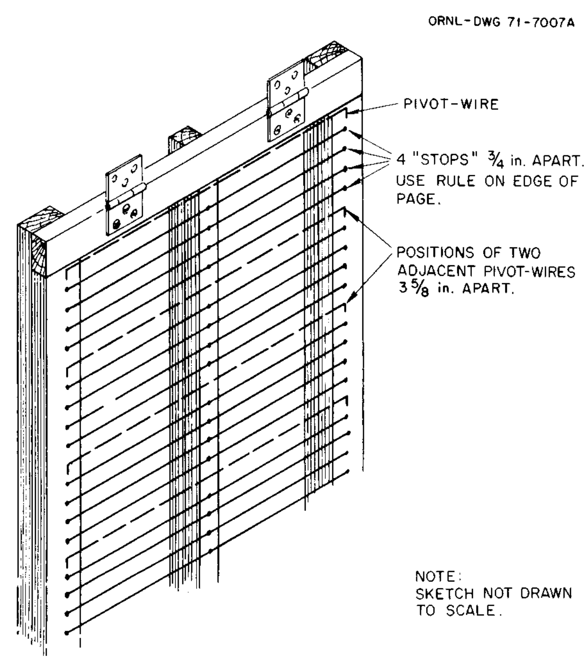
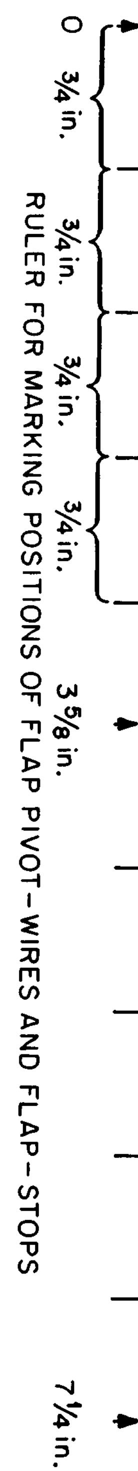


Fig. 11. Positions of pivot-wires and flap-stops.

If you have tacks (NOT thumbtacks) or very small nails, drive three in a horizontal line to attach each flap-stop—one in each of the two vertical 36-in. sides of the frame and one in the vertical center brace (see Fig. 11). First, drive all of these horizontal lines of tacks about three-quarters of the way into the boards. Then, to secure the flap-stop string or thin wire quickly to a tack, wind the string around the tack and immediately drive the tack tightly into the frame to grip the string (see Fig. 11).

If you have no tacks or nails, cut notches or slots where the flap-stops are to be attached. Cut these notches in the edges of the vertical sides of the frame and in an edge of the center brace. Next, secure the flap-stops (strings or wires) by tying each



one in its notched position. This tying should include wrapping each horizontal flap-stop once around the vertical center brace. The stops should be in line with (in the same plane as) the front of the frame. Do not stretch flap-stops too tightly, or you may bend the frame.

5. Final assembly

a. Staple, nail, or tie the 9 flap pivot-wires or pivot-strings (each with its flap attached) in their positions at the marked $3^5/_8$-in. spacings. Start with the lowest flap and work upward (see Fig. 11). Connect each pivot-wire at both ends to the 36-in. vertical sides of the frame. **Also connect it to the vertical brace.** BE CAREFUL TO NAIL THE PIVOT-WIRES ONLY TO THE FRAME AND THE BRACE. DO NOT NAIL ANY PLASTIC DIRECTLY TO THE WOOD. All flaps must turn freely on their pivot-wires.

If any flap, when closed, overlaps the flap below it by more than 1 in., trim off the excess so that it overlaps by only 1 in.

b. Screw (or nail, if screws are not available) the upper halves of the hinges onto the horizontal support board on which the KAP will swing. (A 1-in.-thick board is best, $3^1/_2$ in. wide and at least 12 in. longer than the width of the doorway or other opening in which this KAP is to be installed.)

Be careful to attach the hinges in the UNusual, OUT-OF-LINE POSITION shown in Fig. 12.

CAUTIONS: Do NOT attach a KAP's hinges directly to the door frame. If you do, the hinges will be torn loose on its return stroke or on its power stroke.

If you are making a KAP to fit into a rectangular opening, make its frame 4 in. SHORTER than the height of its opening and 1 in. NARROWER than the width of the opening.

c. For this 3-ft model, tie the pull-cord to the center brace about **$12^1/_2$ in. below the hinge line,** as shown in Fig. 12. (If you tie it lower, your **arm movements will waste energy.**) Use small nails or wire to keep the tie end from slipping up or down on the center brace. (For a more durable connection, see Fig. 22.)

Cut a slot in the flap above the connection of the pull-cord to the vertical brace, deep enough so that this flap will close completely when the KAP is being pulled. Tape the end and edges of the slot.

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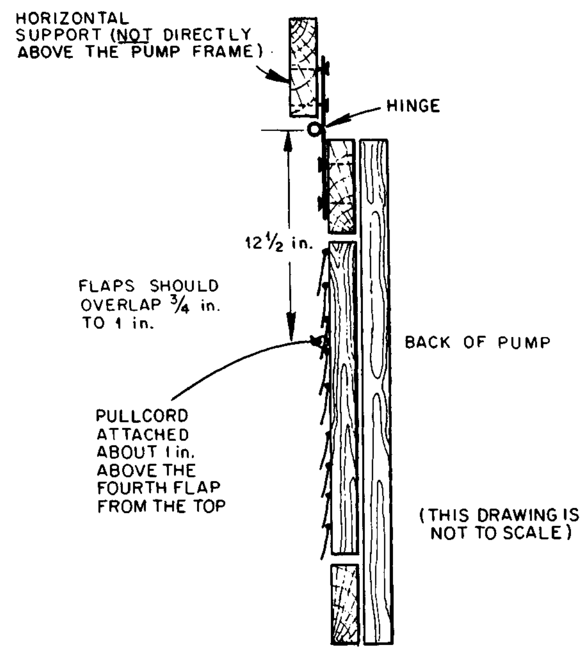

Fig. 12. Hinge is attached so pump can swing 180 degrees.

IV. MORE RAPID CONSTRUCTION

(Skip this section if you cannot easily get chicken wire and $^1/_4$-in.-thick boards.)

If chicken wire and boards about $^1/_4$ in. thick are available, use the chicken wire for flap-stops. By using these materials, the time required to build a given KAP can be reduced by about 40%. One-inch woven mesh is best. (Hardware cloth has sharp points and is unsatisfactory.)

Figure 13 illustrates how the mesh wire should be stapled to the KAP frame. Next, unless the KAP is wider than 3 ft, the front of the whole frame (except for the center brace) should be covered with thin boards approximately $^1/_2$ in. thick, such as laths. Then the pivot-wires, with their flaps on them, should be stapled onto the $^1/_4$-in.-thick boards. This construction permits the flaps to turn freely in front of the chicken-wire flap-stops.

With this design, the center of each pivot-wire should NOT be connected to the center brace, nor should the center of the flap be notched. However, pivot-wires that are attached this way must be made and held straighter than pivot-wires used with flap-stops made of straight strings or wires.

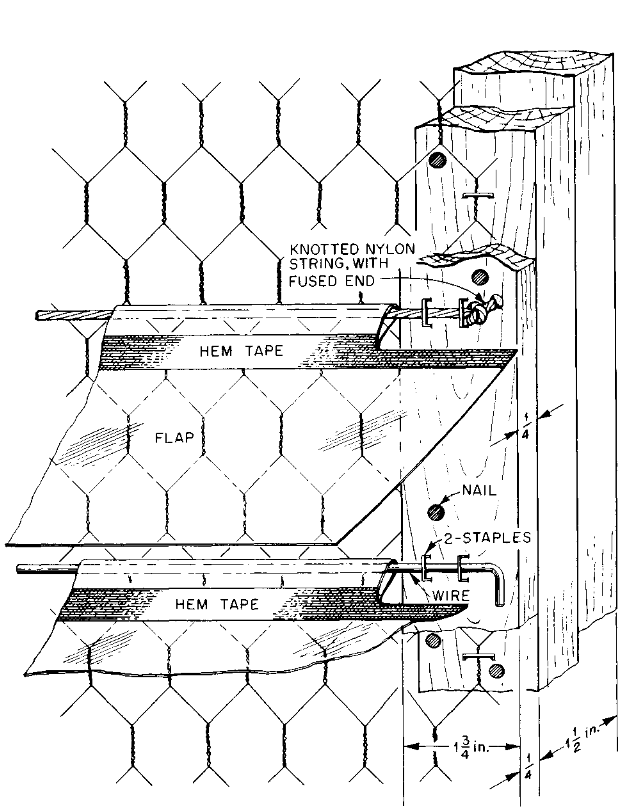

Fig. 13. Flaps attached $^1/_4$ inch in front of chicken wire used for flap-stops.

Note in Fig. 13 that each pivot-wire is held firm and straight by **2** staples securing each end. The wire used should be at least as springy as coat hanger wire. If string is used instead of wire, nylon cord about the diameter of coat hanger wire is best for the pivot-strings.

If the KAP is wider than 3 ft, its center vertical brace should also be covered with a $^1/_4$-in.-thick board, and each pivot-wire should be attached to it. Furthermore, the center of each flap should be notched.

V. INSTALLATION AND ACCESSORIES

A. Minimum Open Spaces Around a KAP

To pump its maximum volume, an air-supply KAP with good metal hinges should be installed in its opening so that it swings only about $^1/_2$ in. above the bottom of the opening and only $^1/_2$ in. to 1 in. from the sides of the opening.

B. Adequately Large Air Passageways

When using a KAP as an air-supply pump to force air through a shelter, it is essential to provide a **low-resistance** air passageway **all the way through** the shelter structure from an **outdoor** air-intake opening for **outdoor** air to a separate air-exhaust opening to the **outdoors** (see Fig. 14).

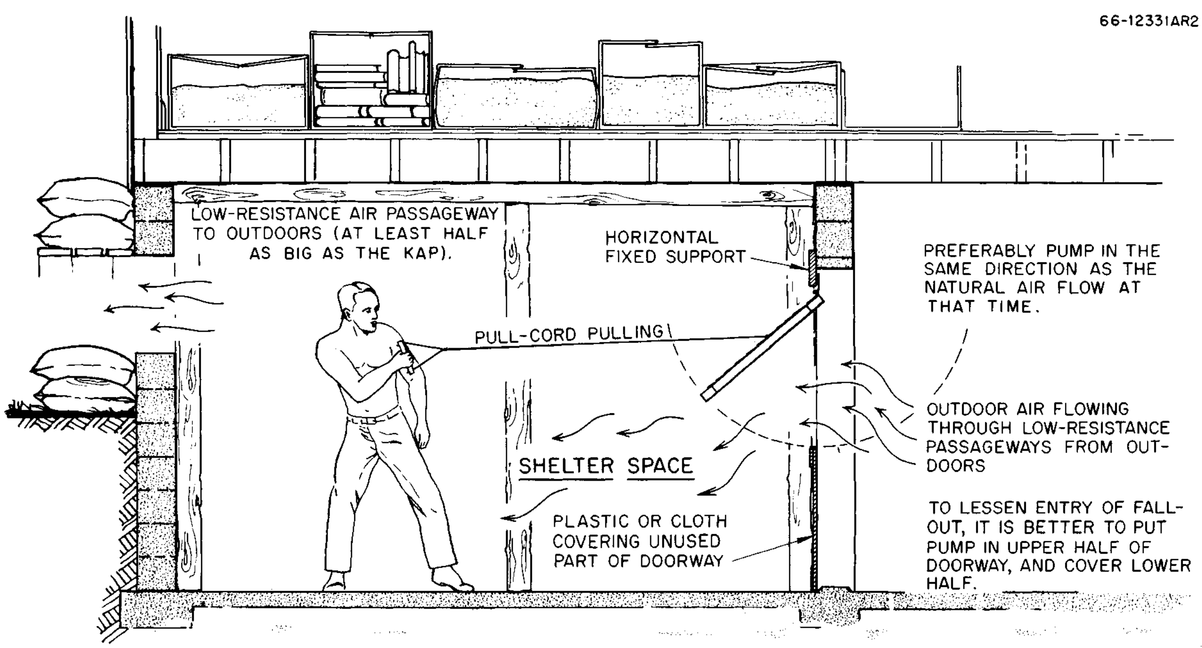

Fig. 14.

A low-resistance air passageway is one that is **no smaller** in cross-sectional area than half the size of the KAP pumping the air. For example, a 36 × 29-in. KAP should have a passageway no smaller than about $3^1/_2$ sq. ft. An air-supply KAP of this size will force at least 1000 cubic feet per minute (1000 cfm) through a shelter having such openings, if it is installed as illustrated in Fig. 14.

If smaller air passageways or air-exhaust openings are provided, the volume of air pumped will be greatly reduced. For example, if the air-exhaust opening is only $1^3/_4$ sq. ft ($^1/_4$ the size of this KAP), then this KAP will pump only about 500 cfm. And if the air-exhaust opening is only a 6 × 6-in. exhaust duct ($^1/_4$ sq. ft), then this same 36 × 29-in. KAP will pump only about 50 cubic feet per minute. This would not provide enough outdoor air for more than one shelter occupant in a well-insulated shelter under heat-wave conditions in the hottest humid parts of the United States. In contrast, when the weather is freezing cold and the shelter itself is still cold enough to absorb the heat produced by the shelter occupants, this same 6 × 6-in. exhaust duct and the air-intake doorway will cause about 50 cfm of outdoor air to flow by itself through the shelter without using any pump. The reason: body heat warms the shelter air, and the warm air rises if cold air can flow in to replace it. Under these **cold** conditions—provided the air is distributed evenly throughout the shelter by KAP or otherwise—50 cfm is enough outdoor air for about 17 people.

To provide adequately large air passageways for air-supply KAPs used to ventilate shelters in buildings, in addition to opening and closing doors and windows, it may be necessary to build large ducts (as described below). Breaking holes in windows, ceilings, or walls is another way to make large, efficient air passageways.

Figure 15 illustrates how a 3-ft KAP can be used as a combined air-supply and air-distribution pump to adequately ventilate a small underground shelter that has an exhaust opening too small to provide enough ventilation in warm weather. (A similar installation can be used to ventilate a basement room having only one opening, its doorway.) Note how, by installing a "divider" in the doorway and entryway, the single entryway is converted into a large air-intake duct and a separate, large air-exhaust duct. To obtain the maximum increased volume of fresh outdoor air that can be pumped through the shelter—a total of about 1000 cfm for a 36 × 29-in. KAP—the divider should extend about 4 ft horizontally into the shelter room, as shown in Fig. 15. The 6 ft at the end of the divider (the almost-horizontal part under the KAP) can be made of plywood, provided it is installed so that it can be taken out of the way in a few seconds.

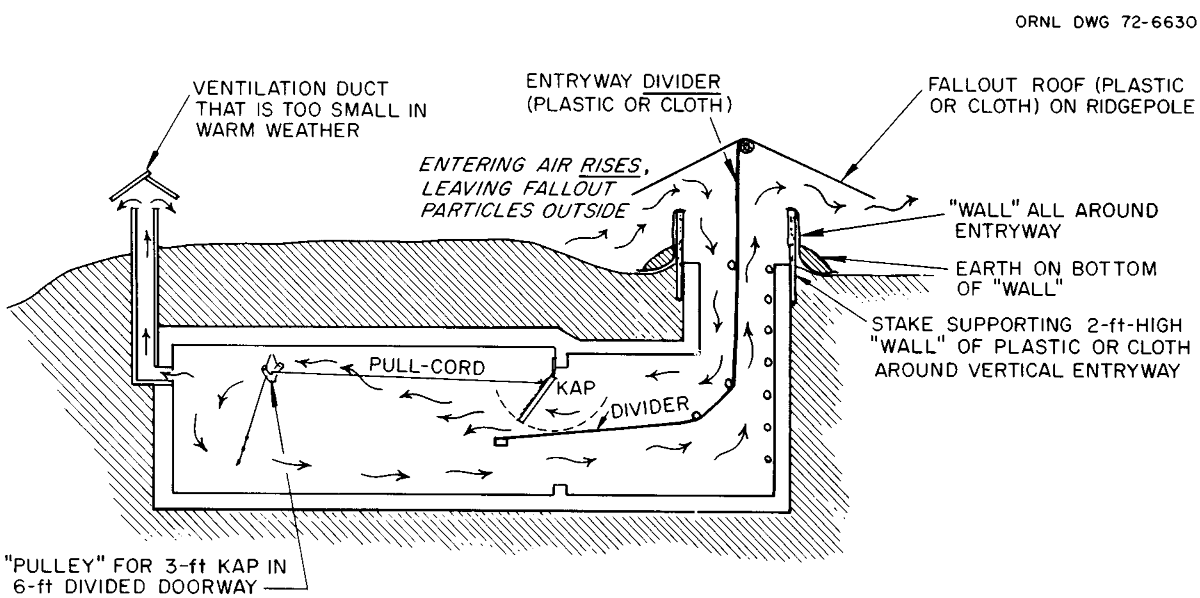

Fig. 15. Ventilating a shelter when the air-exhaust opening is too small.

Note how the entry of fallout into a shelter can be minimized by covering the entryway with a "roof" and by forcing the slow-moving entering air to rise over an obstruction (the "wall") before it flows into the shelter. The sand-like fallout particles fall to the ground outside the "wall."

C. Adequate Distribution of Air Within the Shelter

To make sure that each shelter occupant gets a fair share of the outdoor air pumped through the shelter, **air-distribution KAPs** should be used inside most large shelters. These KAPs are used within the shelter, separate from and in addition to air-supply KAPs (see Fig. 16). Air-distribution KAPs can serve in place of both air-distribution ducts and cooling fans. For these purposes, one or more 3-ft-high KAPs hung overhead from the shelter ceiling are usually most practical. If KAPs cannot readily be hung from the ceiling, they can be supported on light frames made of boards or metal, somewhat like those used for a small child's swing.

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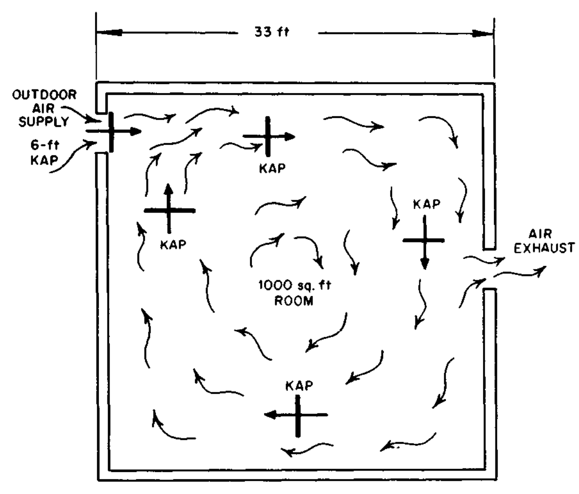

Fig. 16. The use of air-distribution KAPs.

You should make and use enough KAPs to cause air movement that can be felt in all parts of your shelter. Remember that if KAPs are installed near the floor and the shelter is fully occupied, the occupants' bodies will partially block the pumped airflow more than if the same KAPs were suspended overhead.

As a general rule, for shelters having more than about 20 occupants, provide one 3-ft air-distribution KAP for every 25 occupants. In relatively wide shelters, these interior KAPs should be positioned so that they produce an airflow that circulates around the shelter, preventing the air that is being pumped into the shelter from flowing directly to the exhaust opening. Figure 16 illustrates how four KAPs can be used in this way to distribute the air within a shelter and to fan the 100 occupants of a 1000-sq.-ft shelter room. Avoid positioning an air-distribution KAP so that it pumps air in a direction greater than a right angle turn from the direction of airflow to the location of the KAP.

D. Operation with a Pulley

A small KAP—especially one with improvised hinges or one installed at head-height or higher—can be pulled most efficiently by running its pull-cord over a pulley or over a greased homemade "pulley" such as described in Figs. 17 and 18. A pulley should be hung at approximately the same height as the hinges of the KAP, as illustrated in Fig. 15. To make

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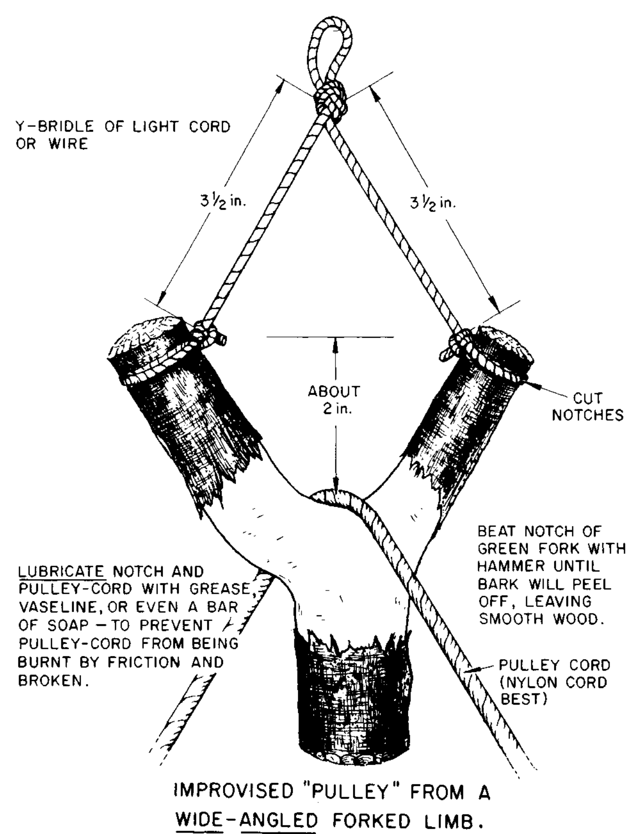

Fig. 17.

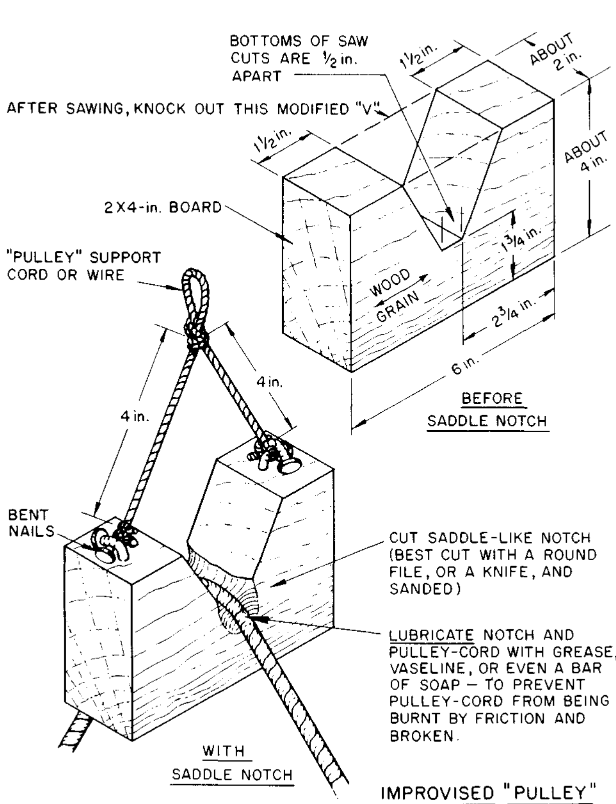

Fig. 18.

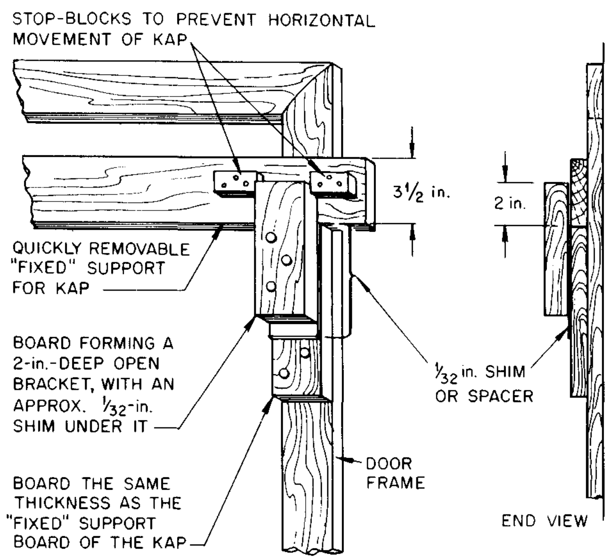

Fig. 19. Quick-removal bracket for KAP.

a comfortable hand-hold on which to pull downward, tie two or three overhand knots in a strip of cloth on the end of the pull-cord.

(Such a "pulley" can also be used to operate a bail-bucket to remove water or wastes from some shelters, without anyone having to go outside.)

E. Quick-Removal Brackets

The air-supply KAP that pumps air through your shelter is best held in its pumping position by mounting it in homemade quick-removal brackets (see Fig. 19) for the following reasons:

- A KAP provided with quick-removal brackets can be taken down easily and kept out of the way of persons passing through its doorway when it is not in use. It can be kept in a place where people are unlikely to damage it.
- By installing two sets of quick-removal brackets in opposite shelter openings, you can quickly reverse the direction in which the KAP pumps air, to take advantage of changes in the direction of natural airflow through the shelter.
- If the KAP is installed on quick-removal brackets, in an emergency a person standing beside the KAP could grasp its frame with both hands, lift it upward a few inches to detach it, and carry it out of the way—all in 3 to 5 seconds. Being able to move the KAP quickly could prevent blast winds from wrecking the pump, which might also be blown into your shelter—possibly injuring occupants. In extensive areas where fallout shelters and their occupants would survive the blast effects of typical large warheads, more than 4 seconds would elapse between the time shelter occupants would see the extremely bright light from the explosion and the arrival of a blast wave strong enough to wreck a KAP or other pumps left exposed in a ventilation opening.

Note in Fig. 19 that the KAP's "fixed" support-board (a $3^1/_2$-in.-wide board to which its hinges are attached) is held in a bracket only 2 inches deep. To prevent too tight a fit in the bracket, be sure to place a $^1/_{32}$-in. shim or spacer (the cardboard back of a writing tablet will do) between two boards of the bracket, as illustrated. Also, make spaces about $^1/_{16}$ inches wide between the lower inner corners of the stop-blocks and the sides of the outer board. To prevent your hands from being cut, you should put tape over the exposed ends of wires near the frame's outer edges of a KAP that you want to be able to remove rapidly.

In a small expedient shelter, a small KAP can be quickly jerked loose if its "fixed" support-board is attached to the roof with only a few small nails.

VI. OPERATION AND MAINTENANCE

A. Pumping

Operate your 3-foot KAP by pulling it with an easy, swinging motion of your arm. To pump the maximum volume of air, you should pull the KAP toward you until its frame swings out to an almost-horizontal position. Then quickly move your hand so that the pull-cord is kept **slack during the entire, free-swinging return stroke.** Figure 24 in Section VIII, LARGE KAPs, illustrates this necessary motion.

Be sure to provide a comfortable hand-hold on the pull-cord (see Fig. 14). Blisters can be serious under unsanitary conditions.

To pull a KAP via an overhead pulley with minimum effort, sit down and pull as if you were tolling a bell—except that you should raise your hand quickly with the return stroke and keep it raised long enough so that the pull-cord remains slack during the entire return stroke. Or, if the pulley is not overhead, operate the KAP by swinging your extended arm back and forth from the shoulder.

B. Placement to Take Advantage of the Natural Direction of Air Flow

A KAP can pump more air into a shelter if it is installed so that it pumps air through the shelter in the direction in which the air naturally flows. Since this direction can be reversed by a wind change outdoors, it is desirable to provide a way to quickly remove your pump and reposition it so that air can be pumped in the opposite direction. This can be done in several ways, including making one set of quick-removal brackets for one air opening and a second set for the other.

C. Maintenance

To operate your KAP efficiently, keep the flaps in good repair and make sure that there is the minimum practical area of open spaces in and around the KAP through which air can flow back around the pump frame, opposite to the pumped direction. So keep at least some extra flap material in your shelter, along with some extra tape and the few tools you may need to make repairs.

VII. NARROW KAPs AND SMALL KAPs

A. Narrow KAPs

To swing efficiently in an entrance or emergency exit of an expedient trench shelter that is 22 in. wide, a KAP is best made 20 in. wide and 36 in. high. One of less height is not as efficient as a 36-in.-high model and has to be pulled uncomfortably fast. So, when ventilation openings can be selected or made at least 38 in. high, make your pump 36 in. high.

In a narrow trench shelter, it is best to have the pull-cord run the full length of the trench, along the trench wall that occupants will face when sitting. Then each occupant can take a turn pulling the pump without having to change seats.

Good metal hinges on a narrow KAP allow it to swing properly if pulled with the pull-cord attached to **one side** of the frame. (Pumps with improvised hinges and large pumps must be pulled from a connection point on their center vertical brace to make them swing properly.) Therefore, if you have small metal hinges and need a KAP no wider than 20 inches, build a rectangular frame **without** a vertical center brace. Make two pull-cord attachment points, one on each side of the frame and each 9 inches below the top of the frame. (For a small KAP, a satisfactory attachment point can readily be made by driving two nails so that their heads cross, and wiring them together.) Then if a change in wind direction outside causes the direction of natural air flow in the trench to become opposite to the direction in which air is being pumped, you can move your KAP to the opening at the other end of the trench. The pull-cord can easily be connected to the other side of the frame, and convenient pumping can be resumed quickly.

So that the horizontal support board can be nailed easily to the roofing poles or boards of an entry trench, it is best to use cabinet hinges. Screw them onto an **edge** of the support board, in the UNusual, OUT-OF-LINE POSITION shown in Fig. 20. This hinge connection allows the pump to swing a full 180 degrees. To facilitate moving the horizontal support board, connect it to the roof with a few small nails, so that it can be pulled loose easily and quickly.

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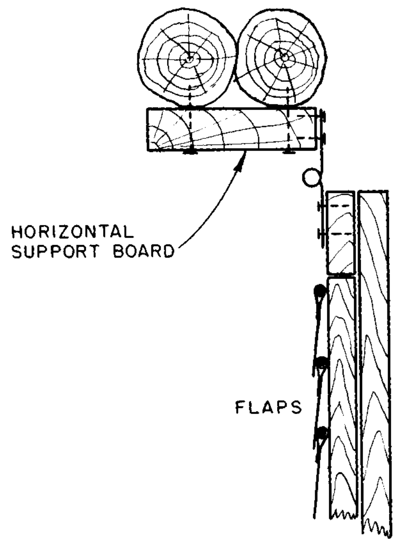

Fig. 20.

B. Small KAPs

If the only available opening in which a KAP can be installed is small, build a KAP to fit it. Use narrower boards to make the frame and make the flaps of thinner material, such as the polyethylene of large plastic trash bags. For pumps 24 inches or less in height, make the finished flaps only 3½ inches wide and space their pivot-wires 3 inches apart. The flaps should overlap no more than ½ inch. A KAP 24 inches high will pump enough outdoor air for only a few people, except in cold weather.

Small, yet efficient KAPs can be made even if the only materials available are straight sticks about 1¼ inches in diameter, strips of cloth to tie the frame together and to make the hinges and the pull cord, polyethylene film from large trash bags for the flaps, freezer or duct tape (or needle and thread) to make the flap hems, coat hanger wire or string for the pivot-wire, and string or ordinary thread for the flap-stops. A sharp knife is the only essential tool. Figure 21 shows a way to easily tie sticks securely together and to attach strings or threads for stop-flaps, when small nails and tacks are not available. The flap-stop strings or threads should be secured by wrapping them several times around each stick to which they are attached, so they will be gripped by the out-of-line knife cuts.

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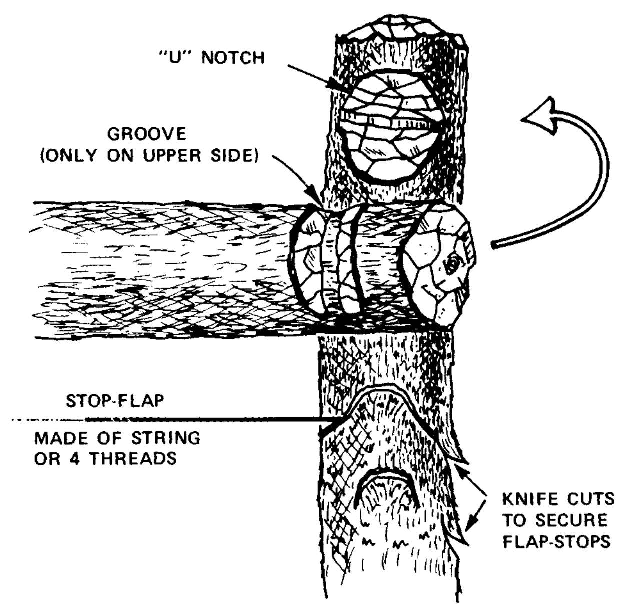

Fig. 21. Sticks ready to be tied together to make a KAP frame.

VIII. LARGE KAPs

A. Construction

A 6-ft-high by 29-in.-wide model can be constructed in the same way as a 3-ft model—except that it should have both horizontal and vertical center braces (1 × 2-in. boards are best). To increase the strength of a 6-ft KAP, all parts of its double-thickness frame and its vertical center brace should be made of two thicknesses of 1 × 2-in. softwood boards, securely held together with clinched nails. Also, to increase the distance that the pump will swing back by itself during its return stroke, it is worthwhile to attach a 6-ft piece of 1 × 2-in. board (not illustrated) to the back of each side of the frame. Do NOT attach weights to the bottom of the frame; this would slow down the pumping rate.

This 6-ft-high pump requires 18 flaps, each the same size as those of the 36-in.-high KAP. The flaps on the lower part of a large KAP must withstand hard use. If $^1/_2$-in.-wide strips of tape are attached along the bottom and side edges of these lower flaps, then even flaps made of ordinary 4-mil polyethylene will remain serviceable for over 1000 hours of pumping. However, the **lower** flaps of large KAPs can advantageously be made of 6-mil polyethylene. The width and spacing of all flaps should be the same as those of the 36-in.-high model.

The pull-cord should be attached to the vertical center brace of a 6-ft KAP about $16^1/_2$ in. below the hinge line. A $^3/_{16}$-in. nylon cord is ideal.

To adequately ventilate and cool very large and crowded shelters in buildings, mines, or caves, KAPs larger than 72 × 29 in. should be used. You can take better advantage of large doorways, elevator shaft openings, etc., by "tailor-making" each large air-supply KAP to the size of its opening—that is, by making it as large as is practical. The frame and brace members should be appropriately strengthened, and one or more "Y" bridles should be provided, as described in the section below. A 7-ft-high × $5^1/_2$-ft-wide KAP, with a $^1/_4$-in.-diameter pull-cord attached 18 in. below its hinge line, and with two "Y" bridles for its two operators, pumped air at the rate of over 11,000 cubic ft per minute through a large basement shelter during tests.

To make a durable connection of the pull-cord to the center vertical brace: (1) Attach a wire loop (Fig. 22) about $16^1/_2$ in. below the hinge line. This loop can be made of coat hanger wire and should go around the center vertical brace. This fixed loop should be kept from slipping on the center brace by bending four 6-penny nails over it in front as illustrated, and two smaller nails in back. (2) Make a free-turning, triple-wire loop connected to the fixed loop. (3) Cover part of the free-turning loop with tape and tie the pull-cord to this loop. Tie the pull-cord tightly over the taped part.

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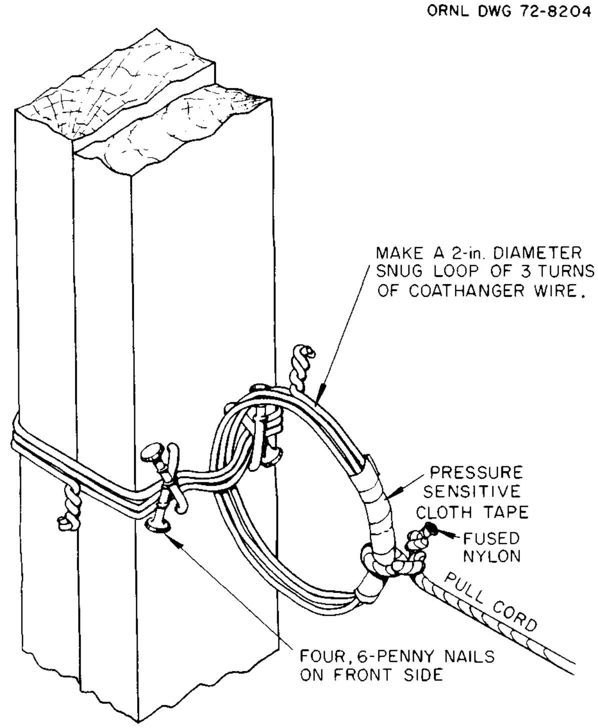

Fig. 22.

B. Operation of Larger KAPs

A larger KAP can be pulled most easily by providing it with a "Y" bridle (see Fig. 23) attached to the end of its pull-cord.

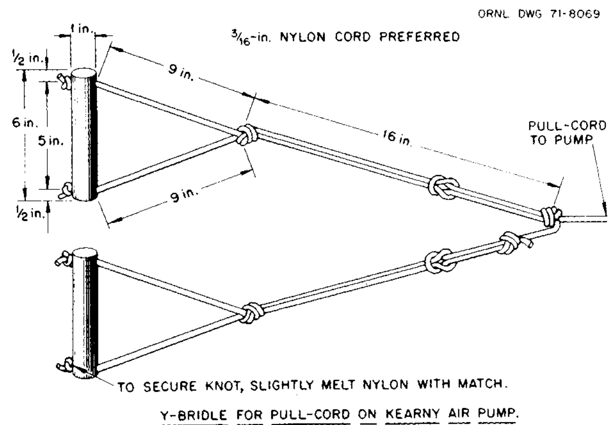

Fig. 23. Y-bridle for pull-cord on KAP.

A man of average size and strength can operate a 6 ft × 29 in. KAP by himself, pumping over 4000 cubic feet per minute through a typical large shelter without working hard; tests have shown that he must deliver only about $^1/_{20}$ of a horsepower. However, most people prefer to work in pairs when pulling a 6-ft KAP equipped with a "Y" bridle, when pumping over 3000 cfm.

To pump the maximum volume of air with minimum effort, study Fig. 24 and follow the instructions given below for operating a large KAP.

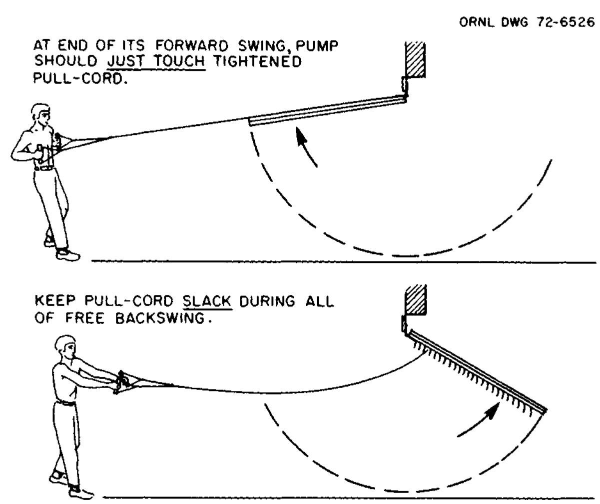

Fig. 24.

1. Gradually start the pump swinging back and forth, moving your arms and body as illustrated and **pulling mostly with your legs and body.**

2. Stand at such a distance from the pump that you can pull the pump toward you until the forward-swinging pump **just touches the tightly stretched pull-cord**—and at such a distance that you can keep the pull-cord **slack** during the whole of the pump's free backswing.

3. To be sure you do not reduce the amount of air pumped, rapidly move your arms forward **as soon as the forward-swinging pump touches the tightened pull-cord.** Hold your arms forward until the pump again starts to swing toward you.

IX. SOLUTIONS TO SPECIAL PROBLEMS

A. Increasing the Usefulness of Shelters by Supplying 40 cfm per Planned Occupant

If a shelter is fully occupied for days during hot weather and is cooled both day and night by pumping through it and distributing at least 40 cubic feet per minute of outdoor air for each occupant—more than is required to maintain tolerable temperatures at night—these advantages result:

- The shelter occupants will be exposed to effective temperatures less than 2° F higher than the current effective temperatures outdoors, and at night will get relief from extreme heat.
- The floors, walls, etc. of a shelter so ventilated will be cooled at night to temperatures well below daytime temperatures. Therefore, during the day a considerable fraction of the occupants' body heat will flow into the floors, walls, and other parts of the shelter and less body heat will have to be carried out by the exhaust air during the hottest hours of the day. Thus daytime temperatures will be reduced.
- Since the shelter occupants will be cooler and will sweat less, especially at night, they will need less water than they would require if the shelter were ventilated at a rate of less than 40 cfm per occupant. (If the outdoor air is very hot and desert-dry, it usually is better to supply less than 40 cfm per occupant during the hottest hours of the day.)
- If the shelter were to be endangered by the entry of outside smoke, carbon monoxide or other poisonous gases, or heavy descending fallout under windy conditions, ventilation of the shelter could be temporarily restricted or stopped for a longer period than would be practical if the shelter itself were warmer at the beginning of such a crisis period.

- The shelter could be occupied beyond its rated capacity without problems caused by overcrowding becoming as serious as would be the case if smaller-capacity air pumps were to be installed and used.

B. Pre-Cooling Shelters

If the shelter itself is cooler than the occupants, more of the body heat of occupants can flow into its cool walls, ceiling, and floor. Therefore, it would be advantageous to pre-cool a shelter that may soon be occupied, especially during hot weather. KAPs (or other air pumps or fans) can be used to pre-cool a shelter by forcing the maximum volume of cooling outdoor air through the shelter and by distributing it within the shelter. A shelter should be pre-cooled at all times when the air temperature outdoors is lower than the air temperature inside the shelter. Then, if the pre-cooled shelter is used, the occupants will be kept cooler at a given rate of ventilation than if the shelter had not been pre-cooled, because the air will not have to carry all of their body heat out of the shelter.

C. Increasing the Effectiveness of a KAP

If you want to increase the volume of air that a KAP with good metal hinges can force through a shelter, install side baffles (see Fig. 25). Side baffles should be rigidly fixed to form two stationary "walls," one on each side of the swinging pump frame. They can be made of plywood, boards, doors, table tops, or even well-braced plastic. A space or clearance of $^1/_2$ to 1 in. should be maintained between the inner side of each baffle and the outer side of the swinging frame.

By installing side baffles you may be able to increase the volume of air your KAP will pump by as much as 20%, if it is in good repair and the openings around it are small.

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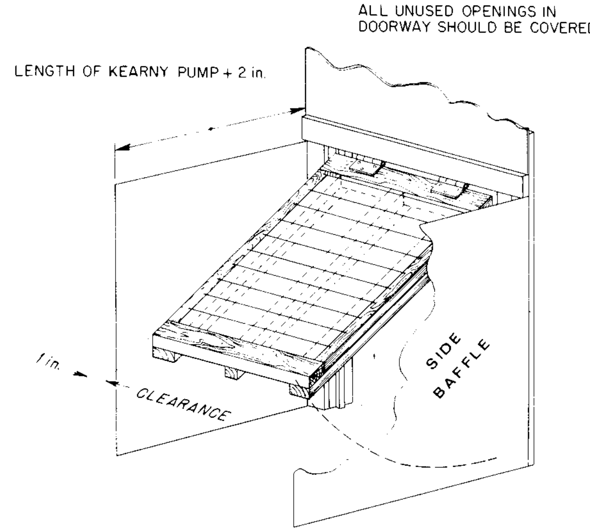

Fig. 25. Side baffles.

D. Operating a KAP as an Exhaust Pump

In some shelters, a KAP can be operated most effectively by using it as an exhaust pump. This can be done by pushing it with a push-pole attached to its center vertical brace. Push-pole operation is sometimes the best way to "suck" outdoor air into a shelter by pumping air out of the shelter in the natural direction of air flow; for example, up an elevator shaft or up a stairwell. This method is especially useful in those basement shelters in which air-intake openings are impractical for installing KAPs. This would be the case if the air-intake openings are small, exposed windows or holes broken in the ceiling of a shelter in a building.

To pump a large KAP most effectively with a push-pole, stand with your back to the KAP and grasp the push-pole with both hands. Using mostly your leg muscles, push the KAP by pulling the free end of its push-pole toward you.

Figure 26 shows an improvised, flexible connection of a push-pole attached to the center brace of a large KAP 28 in. from the top of its frame.

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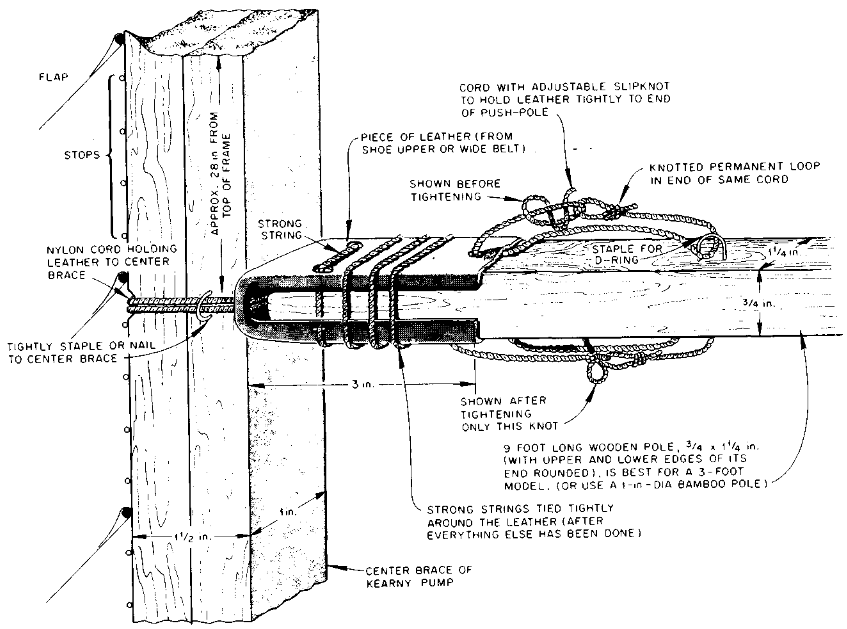

Fig. 26. Push-pole flexible connection.

E. Ventilating a Shelter with Only One Opening

Some basement rooms that may be used as shelters have only one opening, the doorway. A KAP can be used to ventilate such a shelter room if enough well-mixed and distributed air is moving just outside the doorway, or if air from outdoors can be pumped in by another KAP and made to flow in a hallway or room and pass just outside this doorway. Figure 27 indicates how to ventilate such a one-opening room by operating a 3-ft KAP as an air-intake pump in the upper part of the doorway.

Below such a doorway KAP, a "divider" 6 ft to 8 ft long can be installed. The divider permits exhaust air to flow out of the room without much of it being "sucked" back into the room by the KAP swinging above it. Plywood, reinforced heavy cardboard, or even well-braced plastic can be used to make a divider. It should be installed so that, in a possible emergency, it can be jerked out of the way in a few seconds.

When used with a divider, a 36×29 in. KAP can pump almost 1000 cubic feet of air per minute into and out of such a shelter room. Although 1000 cubic feet of well-distributed air is sufficient for several times as many as 25 shelter occupants under most temperate climate conditions, it is enough for only about 25 people in a one-entry room under exceptionally severe heat-wave conditions. Furthermore, to make it habitable for even 25 people under such conditions, the air in this room must be kept from rising more than 2° F above the temperature outdoors. This can be done using a second air-supply KAP to pump enough outdoor air through the building and in some cases also using air-distribution KAPs in spaces outside the one-entry room. The KAP in the doorway of a one-entry room should supply 40 cfm per occupant of this room.

In order to prevent any of the used, warmed, exhaust air from the one-entry room from being "sucked" by the doorway KAP back into the room, a stiffened rectangular duct can be built so as to extend the exhaust-opening (in the lower part of the doorway) several feet outside the room. Such a duct can be built of plastic supported by a frame of small boards. It can be used to discharge the exhaust air far enough away from the KAP and "downstream" in the airflow outside the one-opening room so that no exhausted air can be "sucked" back into the room.

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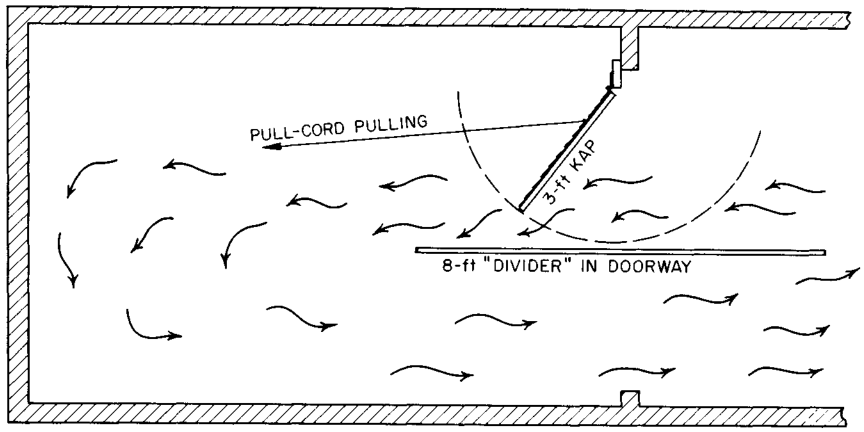

Fig. 27. Use of a "divider" to ventilate a shelter with only one opening.

F. Installing a KAP in a Steel-Framed Doorway

If you need to install a KAP in a steel-framed doorway and it is not feasible to screw or otherwise permanently connect it to the doorway, you can attach the KAP by using a few boards and some cord, as illustrated by Figs. 28 and 29. The two horizontal boards shown extending across the doorway are squeezed tightly against the two sides of the wall in which the doorway is located by tightening two loops of cord, one near each side of the doorway. One loop is illustrated. A cord is first tightened around the two horizontal boards. Then the looped cord is further tightened by binding it in the center with another cord, as illustrated.

Two large "C" clamps serve even better than two looped cords. However, secure support for a swinging KAP still requires the use of a vertical support board on each side of the doorway, as illustrated.

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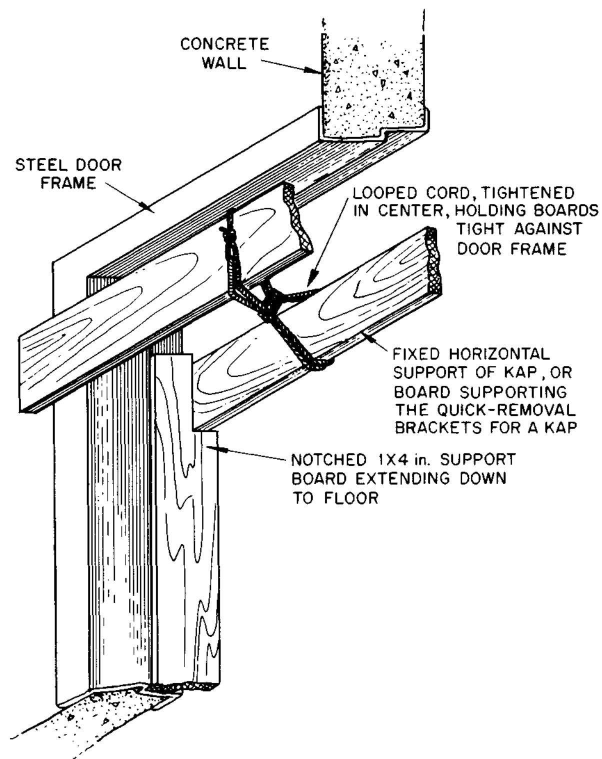

Fig. 28.

Figure 29 shows a quick-removal bracket supported by two horizontal boards tightened across the upper part of a doorway by looped cords, as described above. Also, study Fig. 19 and its accompanying instructions.

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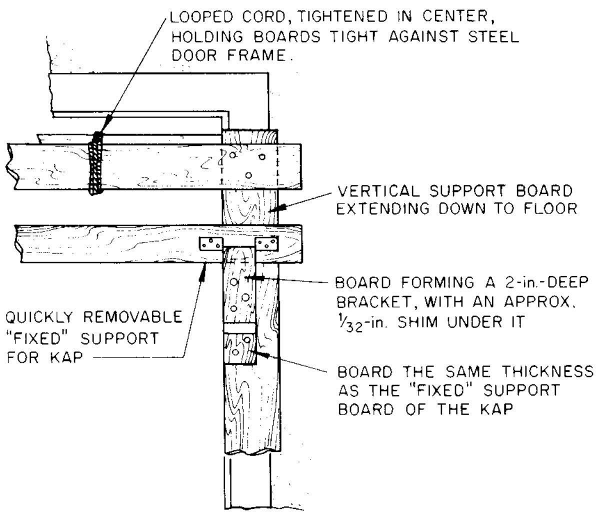


Fig. 29.

G. Building More Durable KAPs

If you are building KAPs in normal times, you may want to use materials that will make your pumps last longer, even though these materials are more difficult to obtain and are more expensive.

Durability tests have shown that the KAP parts that wear out first are the flaps and the pulleys. In 6-ft KAPs, the lower flaps are subject to hard use. Lower flaps made of 6-oz (per sq. yd), clear, nylon-reinforced, plied vinyl have lasted undamaged for over 1000 hours of full-stroke pumping, without having their edges reinforced. Lower flaps made of 6-mil nylon-reinforced polyethylene, without edge reinforcements, have lasted for 1000 hours with only minor damage.

The best pulley tested was a marine pulley such as that used on small sailboats, with a Delrin (DuPont) 2-in.-diameter wheel and 3/16-in. stainless steel shaft. This pulley was undamaged after operating a 6-ft KAP for 324 hours. The pulley appeared to be good for hundreds of hours of further operation.

The best pulley-cords tested were of braided dacron or nylon.

H. Using Air Filters

To supply shelter occupants with filtered air usually would be of **much less** importance to their survival and health than to provide them with adequate volumes of outdoor air to maintain tolerable temperatures. However, filtering the entering air could prove worthwhile, provided:

- Your shelter is not in an area likely to be subjected to blast, or it is a blast shelter with blast doors and blast valves protecting everything inside.
- Work on filters is started *after* you have completed more essential work, including the building of a high-protection-factor shelter, making, installing, and testing the necessary number of KAPs, storing adequate water, making a homemade fallout meter, etc.
- You have enough low-resistance filters (such as fiberglass dust filters used in furnaces and air-conditioners) and other materials for building the necessary large, supported filter in front of your KAP.
- Your KAP can pump an adequate volume of air through the filter and shelter.
- The filter is installed so that it can be easily removed if shelter temperatures rise too high.

To prevent a filter used with a KAP from causing too great a reduction in the volume of air that the KAP can pump through your shelter, you must use **large areas of low-resistance filter material.** An example: In one ventilation test, a large basement shelter was used which had two ordinary doorways at its opposite ends. These served as its air-intake and its air-exhaust openings. A 72×29 in. KAP operating in one doorway pumped almost 5000 cubic feet per minute through the shelter. But when a filter frame holding 26 square feet of 1-in.-thick fiberglass dust filters was placed across the air-intake stairwell, the KAP could pump only about 3400 cfm through this filter and the shelter.

Chapter 6
Ventilation and Cooling of Shelters

CRITICAL IMPORTANCE

If high-protection-factor shelters or most other shelters that lack adequate forced ventilation were fully occupied for several days in warm or hot weather, they would become so hot and humid that the occupants would collapse from the heat if they were to remain inside. It is important to understand that the heat and water vapor given off by the bodies of people in a crowded, long-occupied shelter could be deadly if fallout prevents leaving the shelter.

When people enter an underground shelter or basement in the summertime, at first the air feels cool. However, if most shelters are fully occupied for a few days without adequate ventilation, the floors, walls, and ceilings, originally cool, will have absorbed about all the body heat of which they are capable. Some shelters will become dangerously hot in a few hours. Unless most of the occupants' body heat and water vapor from sweat are removed by air circulated through a typical shelter, the heat-humidity conditions will become increasingly dangerous in warm or hot weather. One of the most important nuclear war survival skills people should learn is how to keep occupied shelters adequately ventilated in all seasons and cool enough for many days of occupancy in warm or hot weather. Methods **for ventilating with homemade devices and for keeping ventilating air from carrying fallout particles into shelters are described in Appendices A and B. Instructions for Directional Fanning, the simplest means for forcing adequate volumes of air to flow through shelters, are given at the end of this chapter.**

MAKING AND USING AN EXPEDIENT AIR PUMP

The best expedient way to maintain livable conditions in a shelter, especially in hot weather, is to make and use a large-volume shelter-ventilating pump. Field tests have proved that average Americans can build the expedient air pump described in Appendix B in a few hours, with inexpensive materials found in most households.

This simple pump was invented in 1962 by the author. I called it a Punkah-Pump, because its hand-pulled operation is somewhat like that of an ancient fan called a "punkah", still used by some primitive peoples in hot countries. (Unlike the punkah, however, this air pump can force air to move in a desired direction and is a true pump.) It was named the Kearny Air Pump (KAP) by the Office of Civil Defense following tests of various models by Stanford Research Institute, the Protective Structures Development Center, and General American Transportation Company. These tests confirmed findings first made at Oak Ridge National Laboratory regarding the advantages of the KAP both as a manually operated pump for forcing large volumes of outdoor air through shelters and as a device for distributing air within shelters and fanning the occupants. See Fig. 6.1.

The air pump instructions given in Appendix B are the result of having scores of families and pairs of untrained individuals, including children, build and use this air pump. They were guided by successively improved versions of these detailed, written instructions, that include many illustrations (see Appendix B). Some people who are experienced at building things will find these instructions unnecessarily long and detailed. However, shelter-building experiments have shown that the physically stronger individuals, usually the more experienced builders, should do more of the hard, manual work when shelters are built, and that those less experienced at building should do the lighter work—including making shelter-ventilating pumps. These detailed, step-by-step instructions have enabled people who never

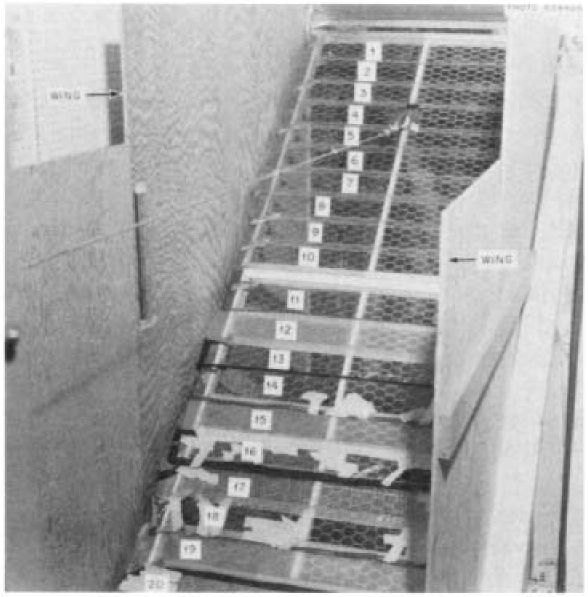


Fig. 6.1. A 6-foot KAP tested for durability at Oak Ridge. After 1000 hours of operation during which it pumped air through a room at a rate of 4000 cubic feet per minute (4000 cfm), there were only minor tears in the plastic flaps.

Fig. 6.2. Behind the girl is the homemade air pump that made it possible for a family of six to live in a crowded trench shelter for more than three days. Outside the temperature rose to 93° F.

before had attempted to build a novel device of any kind to make serviceable air pumps.

(The air pump instructions given in Appendix B repeat some information in this chapter. This repetition is included both to help the reader when he starts to build an air pump and to increase the chances of the best available complete instructions being given to local newspapers during some future crisis. The instructions given in this book could be photographed, reproduced, and mass-distributed by newspapers.)

Figure 6.2 shows (behind the girl) a 20-inch-wide by 36-inch-high KAP installed in the entry trench of a trench shelter. The father of the Utah family described earlier had made this simple pump at home, using only materials and tools found in many homes—as described in Appendix B. He carried the pump on top of his car to the shelter-building site. The pendulum-like, flap-valve pump was swung from two cabinet hinges (not shown) screwed onto a board. The board was nailed to roof poles of the narrow entry trench extending behind the girl in the photograph. The pull-cord was attached to the pump frame below its hinged top and extended along one trench wall for the whole length of the shelter. Any one of the six occupants could pull this cord and easily pump as much as 300 cubic feet per minute of outdoor air through the shelter and through the insect screens over both its entrances. (Without these screens, the numerous mosquitoes in this irrigated area would have made the family's shelter stay very unpleasant.)

During the 77 hours that the family continuously occupied their narrow, covered trench, the temperatures outside rose as high as 93° F. Without the air pump, the six occupants would have been driven from their shelter by unbearable temperature-humidity conditions during the day.[8]

The photo in Fig. 6.2 also shows how the air pump hung when not being operated, partially blocking the entry trench and causing a "chimney effect" flow of air at night. There was a 10-inch space between the air pump and the trench floor, and the resulting flow of air maintained adequate ventilation in the cool of the desert night, when outdoor temperatures dropped as low as 45° F. Cool outdoor air flowed down into the entry and under the motionless air pump, replacing the body-warmed air inside the shelter. The entering cool air continuously forced the warm air out of the shelter room at ceiling height through the emergency crawlway-exhaust trench at the other end. When the weather is cool, a piece of plastic or tightly woven cloth could be hung in the doorway of a well designed, narrow shelter, to cause a flow of fresh air in the same manner.

Numerous shelter occupancy tests have proved that modern Americans can live for weeks in an adequately cooled shelter with only 10 square feet of floor space per person.[13] Other tests, such as one conducted by the Navy near Washington, D.C. during an abnormally cool two weeks in August, 1962, have shown that conditions can become difficult even when summertime outdoor air is being pumped through a long-occupied shelter at the rate of 12 cubic feet per minute, per person.[14,15] This is four times the *minimum* ventilation rate for each occupant specified by the Federal Emergency Management Agency (FEMA) for American shelters: 3 cubic feet per minute (3 cfm). Three cfm is about three times the supply of outdoor air needed to keep healthy people from having headaches as a result of exhaled carbon dioxide. In hot, humid weather, much more outdoor air than 12 cfm per person must be supplied to a crowded, long-occupied shelter, as will be described in the following section and in Appendix B.

MAINTAINING ENDURABLE SHELTER CONDITIONS IN HOT WEATHER

The Navy test mentioned above showed how much modern Americans who are accustomed to air conditioning could learn from jungle natives about keeping cool and healthy by skillfully using hot, humid, outdoor air. While working in jungles from the Amazon to Burma, I observed the methods used by the natives to avoid unhealthful conditions like those experienced in the Navy shelter, which was ventilated in a conventional American manner. These jungle methods include the first five of the six cooling methods listed in this section. During 24 years of civil defense research, my colleagues and I have improved upon the cooling methods of jungle people, primarily by the invention and thorough field-testing of the homemade KAP described in Appendix B, and of the Directional Fans covered by the instructions at the end of this chapter.

Even during a heat wave in a hot part of the United States, endurable conditions can be maintained in a fully occupied, belowground shelter with this simple pump, if the test-proven requirements listed below are ALL met.

Most basement shelters and many aboveground shelters also can be kept at livable temperatures in hot weather if the cooling methods listed below are ALL followed:

- Supply enough air to carry away all the shelter occupants' body heat without raising the "effective temperature" of the air at the exhaust end of the shelter by more than 2°F. The "effective temperature" of the air to which a person is exposed is equivalent to the temperature of air at 100% relative humidity that causes the same sensation of warmth or cold. "Effective temperature" combines the effects of the temperature of the air, its relative humidity, and its movement. An ordinary thermometer does not measure effective temperature. In occupancy tests of crowded shelters when the supply of outdoor air was hot and dry, shelter occupants have been surprised to find that they felt hottest at the air-exhaust end of their shelter, where the temperature reading was lower than at the air-intake end. Their sweaty bodies had acted as evaporative air coolers, but their body heat had raised the effective temperature, a reliable indicator of heat stress. If 40 cubic feet per minute (40 cfm) per person of outdoor air is supplied and properly distributed, then (even if the outdoor air is at a temperature which is typical of the hottest hours during a heat wave in a hot, humid area of the United States) the effective temperature of the shelter air will be increased no more than 2°F by the shelter occupants' body heat and water vapor. Except for a relatively few sick people dependent on air conditioning, anyone could endure air that has an effective temperature only 2°F higher than that of the air outdoors.

(There are exceptions to this ventilation requirement when the ceiling or walls of basement or aboveground shelters in buildings are heated by the sun to levels higher than skin temperature. In such shelters, more than 40 cfm of outdoor air per occupant must be supplied. However, if a shelter is covered by at least two feet of earth, it will be so well insulated that its ceiling and walls will not get hot enough to heat the occupants.)

- Move the air gently, so as not to raise its temperature. In the aforementioned Navy test, a high speed, electric ventilating pump and the frictional resistance of pipes and filters raised the temperature of the air supplied to the shelter by 3°F. Under extreme heat wave conditions, an air supply 3°F hotter than outdoor air could be disastrous—especially if considerably less than 40 cfm per occupant is supplied, and body heat raises the air temperature several additional degrees.

- Distribute the air quite evenly throughout the shelter. In a trench shelter, where air is pumped in at one end and flows out the other, good distribution is assured. In larger shelters, such as basements, ventilating air will move from the air-supply opening straight to the air-exhaust opening. Persons out of this air stream will not be adequately cooled. By using one or more additional, smaller KAPs (also described in Appendix B), fresh air can be distributed easily throughout large shelter rooms, and the occupants will be gently fanned.

- Provide occupants with adequate drinking water and salt. In extremely hot weather, this means 4 quarts of water per day per person and 1 tablespoon (10 grams) of salt, including the salt in food.

- Wear as few clothes as practical. When the skin is bare, moving air can evaporate sweat more efficiently for effective cooling. Air movement can keep bare skin drier, and therefore less susceptible to heat rash and skin infections. In the inadequately ventilated Navy test shelter, 34 of the 99 initially healthy young men had heat rash and 23 had more serious skin complaints at the end of their sweaty two-week confinement, although their overall physical condition had not deteriorated.[15] However, at sick call every day all of these Navy test subjects with skin complaints were treated by medical corpsmen. In a nuclear war, very few shelter occupants would have medicines to treat skin diseases and infections, that if not taken care of usually worsen rapidly under continuously hot, humid conditions. Simple means for preventing skin diseases and infections—means proved very effective by jungle natives and by our best trained jungle infantrymen in World War II — are described in the Prevention of Skin Diseases section of Chapter 12.

- Keep pumping about 40 cfm of air per person through the shelter both day and night during hot weather, so that the occupants and the shelter itself will be cooled off at night. In the Navy test, the ventilation rate of 7 to 12 cfm was not high enough to give occupants the partial relief from heat and sweating that people normally get at night.[15] In a National Academy of Sciences meeting on protective shelters, an authority stated: "Laboratory experiments and field investigations have shown that healthy persons at rest can tolerate daily exposures to ETs [effective temperatures] up to 90° F, provided they can get a good night's sleep in a cooler environment."[14] An effective temperature 90° F is higher than the highest outdoor effective temperature during a heatwave in the South or in American deserts.

ADEQUATE VENTILATION IN COLD WEATHER

In freezing weather, a belowground shelter covered with damp earth may continue to absorb almost all of its occupants' body heat for many days and stay unpleasantly cold. In one winter test of such a fully occupied shelter, the temperature of the humid air in the shelter remained around 50° F.[16] Under such conditions, shelter occupants should continue to ventilate their shelter adequately, to avoid the following conditions:

- A dangerous buildup of carbon dioxide from exhaled breath, the first symptoms of which are headaches and deeper breathing.
- Headaches from the carbon monoxide produced by smoking. When the ventilation rate is low, smoking should not be permitted, even near the exhaust opening.
- Headaches, collapse, or death due to carbon monoxide from open fires or gasoline lanterns that release gases into the shelter air.

NATURAL VENTILATION

Enough air usually will be blown through an aboveground shelter if sufficiently large openings are provided on opposite sides and if there is any breeze. But if the weather is warm and still and the shelter crowded, the temperature-humidity conditions soon can become unbearable.

Adequate natural ventilation for belowground shelters is more difficult. Even if there is a light breeze, not much air will make a right-angle turn and go down a vertical entry, make another right-angle turn, and then flow through a trench or other shelter partially obscured by people and supplies.

In cool weather, occupants' body heat will warm the shelter air and make it lighter than the outdoor air. If a chimney-like opening or vent-duct is provided in the ceiling, the warmed, lighter air will flow upward and out of the shelter, provided an adequate air-intake vent is open near the floor. An Eskimo igloo is an excellent example of how very small ventilation openings, skillfully located in the ceiling and at floor level, make it possible in cold weather for chimney-type natural ventilation to supply the 1 cfm per person of outdoor air needed to prevent exhaled carbon dioxide from becoming dangerously concentrated.

In warm weather, chimney-type natural ventilation usually is inadequate for most high-protection-factor shelters that are fully occupied for days. And in hot weather, when as much as 40 cfm per occupant is required, body-warmed shelter air is no lighter than the outdoor air. Chimney-type ventilation fails completely under these conditions.

SHELTER VENTILATION WITHOUT FILTERS

Numerous tests have shown that the hazards from fallout particles carried into shelters by unfiltered ventilating air are minor compared to the dangers from inadequate ventilation. A 1962 summary of the official standards for ventilating systems of fallout shelters stated: "Air filters are not essential for small (family size) shelters . . . "[17] More recent findings have led to the same conclusion for large fallout shelters. A 1973 report by the Subcommittee on Fallout of the National Academy of Sciences on the radioiodine inhalation problem stated this conclusion: "The opinion of the Subcommittee is that inhalation is far less of a threat than ingestion [eating or drinking], and does not justify countermeasures such as filters in the ventilating systems of shelters."[18]

Recommendations such as those above realistically face the fact that, if we suffer a nuclear attack, the vast majority of Americans will have only the fallout protection given by buildings and some expedient shelters. Consequently, how best to use available resources must be the primary consideration when planning for protection against the worst dangers of a nuclear attack; relatively minor hazards may have to be accepted. For unprepared people, inhalation of fallout particles would be a minor danger compared to being forced out of a shelter because of dangerously inadequate ventilation.

The most dangerous fallout particles are those deposited on the ground within the first few hours after the explosion that produces them. Typically, these "hot" particles would be so large and fast-falling that they would not be carried into expedient shelters equipped with low-velocity air intake openings, such as those described in this book. Nor would these most dangerous "hot" fallout particles be "sucked" into gooseneck air-intake pipes, or other properly designed air-intake openings of a permanent shelter.

For most shelters built or improved hurriedly during a crisis it will be impractical to provide filtered air. The Car-Over-Trench Shelter pictured in Fig. 6.3 points up the overriding need for pumped air for occupants of crowded shelters during warm or hot weather. This simple shelter provides fallout protection about four times as effective as that given by a typical home basement. After the car was driven over the trench, earth was shoveled into the car and its trunk and on top of its hood. At one end was a combined crawlway entrance/air intake opening, at the other end, a 1-foot-square air exhaust opening. Each opening was covered by a small awning. To keep loose shielding earth from running under the car and into the trench, the upper edges of 5-foot-wide strips of polyethylene film first were attached with duct tape to the sides and ends of the car, about 2 feet above the ground. Then earth was piled onto the parts of the film strips that were lying on the ground, to secure them. Finally, earth was piled against the vertical parts of the attached film strips.

Fig. 6.3. Pulling a Small, Stick-Frame KAP to Keep Temperatures Endurable for Occupants of a Car-Over-Trench Shelter in Warm Weather. Enough air also can be supplied with a small Directional Fan, although more laboriously.

(Placing earth rolls — see page 150 — around the sides of an earth-loaded car provides better, more secure side shielding, but requires more materials and work.)

INHALATION DANGERS

Only extremely small fallout particles can reach the lungs. The human nose and other air passages ". . . can filter out almost all particles 10 micrometers [10 microns] [or larger] in diameter, and about 95 percent of those exceeding 5 micrometers." (See reference 6, page 599.) Five micrometers equal 5 millionths of a meter, or 5 thousandths of a millimeter.

Using a dust mask or breathing through cloth would be helpful to keep from inhaling larger "hot" fallout particles which may cause beta burns in noses, sinuses, and bronchial tubes. Many such retained particles may be swallowed when cleared from one's air passageways by the body's natural protective processes.

As shown below in Fig. 6.4, a relatively "large" particle — 40 microns (40 μ m) in diameter, spherical, and with the sand-like density of most fallout particles — falls about 1300 feet in 8 hours. (A dark-colored particle 40 microns in diameter is about as small a speck as most people can see with the naked eye.) Most 40-μ m-diameter fallout particles would take a

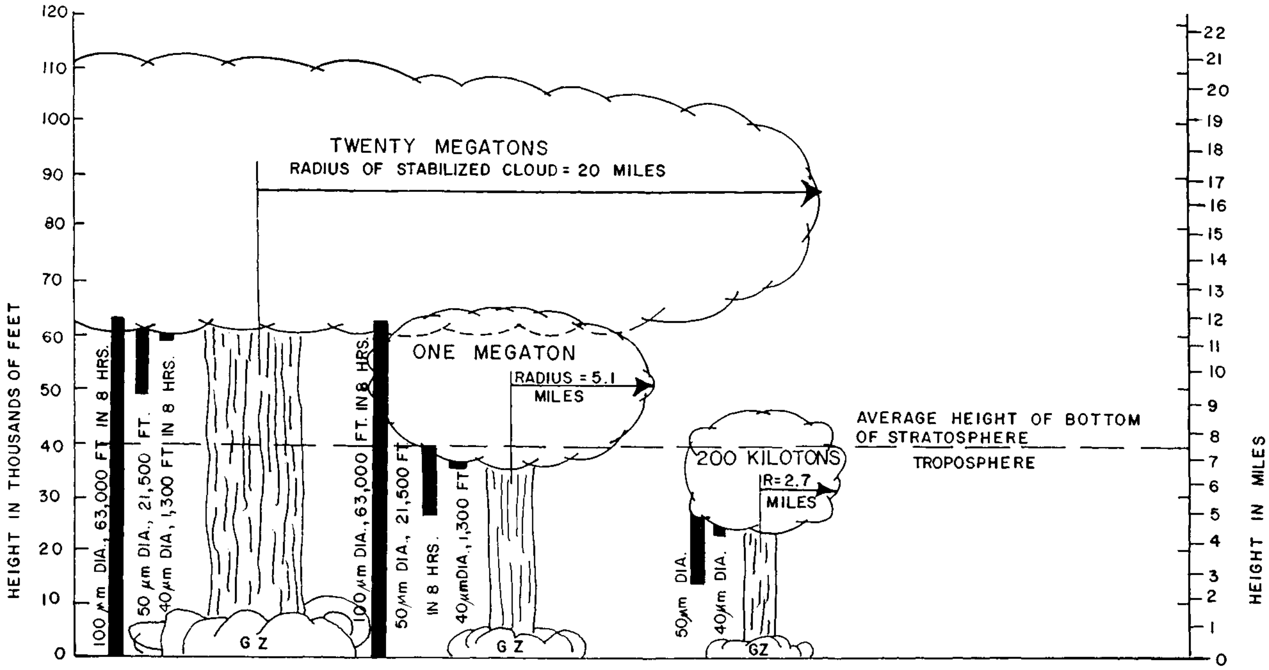


Fig. 6.4. Stabilized Radioactive Fallout Clouds Shown a Few Minutes After the Explosions, with distances that spherical fallout particles having diameters of 40, 50, and 100 microns fall in 8 hours.[6]

few days to fall from the cloud of a one-megaton explosion down far enough into the troposphere to be occasionally scavenged and promptly brought to earth by rain or snow while still very radioactive. In 1987, however, most of the thousands of deployed Soviet ICBM warheads are 550 kilotons or smaller. (See *Jane's Weapon Systems, 1987-88.*) The stabilized clouds of such explosions would be mostly in the troposphere, and some of even the tiniest particles — those small enough to be breathed into one's lungs — would be promptly scavenged and deposited in scattered "hot spots." Fortunately, most of the very small and tiniest fallout particles would not be deposited for days to months, by which time radioactive decay would have made them much less dangerous. Breathing tiny radioactive particles into one's lungs would constitute a minor health hazard compared to other dangers that would afflict an unprepared people subjected to a large scale nuclear attack.

SCAVENGING OF RADIOACTIVE PARTICLES

Scavenging is most effective below about 30,000 feet, the maximum height of most rain and snow clouds. See Fig. 6.4. Because the Soviets have deployed thousands of ICBMs with warheads of "only" 100 to 550 kilotons, Americans face increased dangers from very radioactive particles scavenged by rain-outs or snow-outs. The resultant "hot spots" of fallout heavy enough to kill unsheltered people in a few weeks could be scattered even hundreds of miles downwind from areas of multiple explosions, especially missile fields. Prudent Americans, even those living several hundred miles from important targets, whenever practical should equip their shelters with adequate ventilating pumps and dust filters.

This potential danger from extremely small fallout particles will be worsened if the United States deploys mobile ICBMs such as Midgetman, probably on large military reservations in the West. (The Soviet Union already has mobile ICBMs in its nuclear forces.) In the event of a Soviet attack, our hard-to-target mobile missiles probably would be subjected to a barrage of relatively small warheads air-bursted so as to blanket their deployment areas. The resultant large clouds of extremely small radioactive particles in the troposphere usually would be blown eastward, and resultant life-endangering "hot spots" from rain-outs and/or snow-outs could be scattered clear to the Atlantic coast.

Fortunately, even in many expedient shelters completed in a few days, filtered air can be provided by using a homemade KAP to pump air through furnace or air-conditioner filters, as described in the last section of Appendix B. To learn how you can supply a shelter at low cost with air so well filtered that essentially all extremely small fallout particles and infective aerosols are removed, see Appendix E, How To Make a Homemade Plywood Double-Action Piston Pump and Filter.

These worsening potential dangers from extremely small "hot" fallout particles brought promptly to earth by scavenging are not likely to endanger nearly as many Americans' lives as would 24-hour fallout of much larger particles from surface and near-surface explosions. Providing enough outdoor air to shelters, rather than filtered air, will continue to deserve first priority.

STOPPING OR RESTRICTING SHELTER VENTILATION

When instrument readings or observations show that heavy fallout has begun to be deposited, shelter occupants should decide whether to restrict or stop ventilation. If it is windy outside, even some sand-like fallout particles may be blown into a shelter with large ventilation openings. However, ventilation should not be restricted long enough to cause weaker occupants to be on the verge of collapse from overheating, or to result in headaches from exhaled carbon dioxide.

If a house is burning dangerously close to a separate, earth-covered shelter, closing the shelter's ventilation openings for an hour or two usually will prevent the entry of dangerous concentrations of carbon monoxide, carbon dioxide, or smoke. (Most houses will burn to the ground in less than two hours.)

When an attack is expected, a shelter, occupied or soon to be occupied, should be kept as cool as practical by pumping large volumes of outdoor air through it when the outdoor air is cooler than the shelter air. This also will assure that the air is fresh and low in exhaled carbon dioxide. Then, if a need arises to stop or restrict ventilation, the shelter can be closed for longer than could be done safely otherwise.

VENTILATION/COOLING OF PERMANENT SHELTERS

A permanent family fallout shelter, built at moderate cost before a crisis, should have a ventilation system that can supply adequate volumes of either filtered or unfiltered air, pumped in through an air-intake pipe and out through an air-exhaust pipe. Provision also should be made for the grim possibility that fallout could be so heavy that a shelter might have to be occupied for weeks, or even part-time for months. A small or medium-sized permanent shelter should be designed so that most of the time after an attack it can have adequate natural ventilation through its entryway and emergency exit. During hot spells, forced ventilation through these same large air passageways should be provided by using a homemade KAP. This manual air pump, described in Appendix B, can force large volumes of air through low-resistance openings with minimum effort.

Ways to ventilate and cool permanent shelters are described in Chapter 17, "Permanent Family Fallout Shelters for Dual Use," and in Appendix E, "How to Make and Use a Homemade Plywood Double-Action Piston Pump and Filter."

WARNING: MANY OFFICIAL INSTRUCTIONS FOR BUILDING AND VENTILATING SHELTERS ARE LIFE-ENDANGERING

The reader is advised not to read this section if pressed for time during a crisis, unless he is considering building an expedient or permanent shelter described in an official civil defense publication.

Because of the worldwide extreme fear of radiation, civil defense specialists who prepare official self-help instructions for building shelters have made radiation protection their overriding objective. Apparently the men in Moscow and Washington who decide what shelter-building and shelter-ventilating instructions their fellow citizens receive — especially instructions for building and improving expedient shelters—do not understand the ventilation requirements for maintaining endurable temperature/humidity conditions in crowded shelters. It must be remembered that shelters may have to be occupied continuously for days in warm or hot weather.

Russian small expedient shelters are even more dangerously under-ventilated than are most of their American counterparts, and can serve to illustrate similar ventilation deficiencies of American shelters. Figure 6.5 is a Russian drawing (with its caption translated) of a "Wood-Earth Shelter" in a Soviet self-help civil defense booklet, "Anti-Radiation Shelters in Rural Areas." This booklet, published in a 200,000-copy edition, includes illustrated instructions for building 20 different types of expedient shelters. All 20 of these shelters have dangerously inadequate natural ventilation, and none of them have air pumps. Note that this high-protection-factor, covered-trench shelter depends on air flowing down through its "Dust Filter with Straw Packing (hay)" and out through its small "Exhaust Duct with Damper."

As part of Oak Ridge National Laboratory's participation in Defense Nuclear Agency's "Dice Throw" 1978 blast test, I built two Russian Pole-Covered Trench Shelters. These were like the shelter shown in Fig. 6.5, except that each lacked a trapdoor and filter. As anticipated, so little air flowed through these essentially dead-ended test shelters that temperatures soon became unbearable.

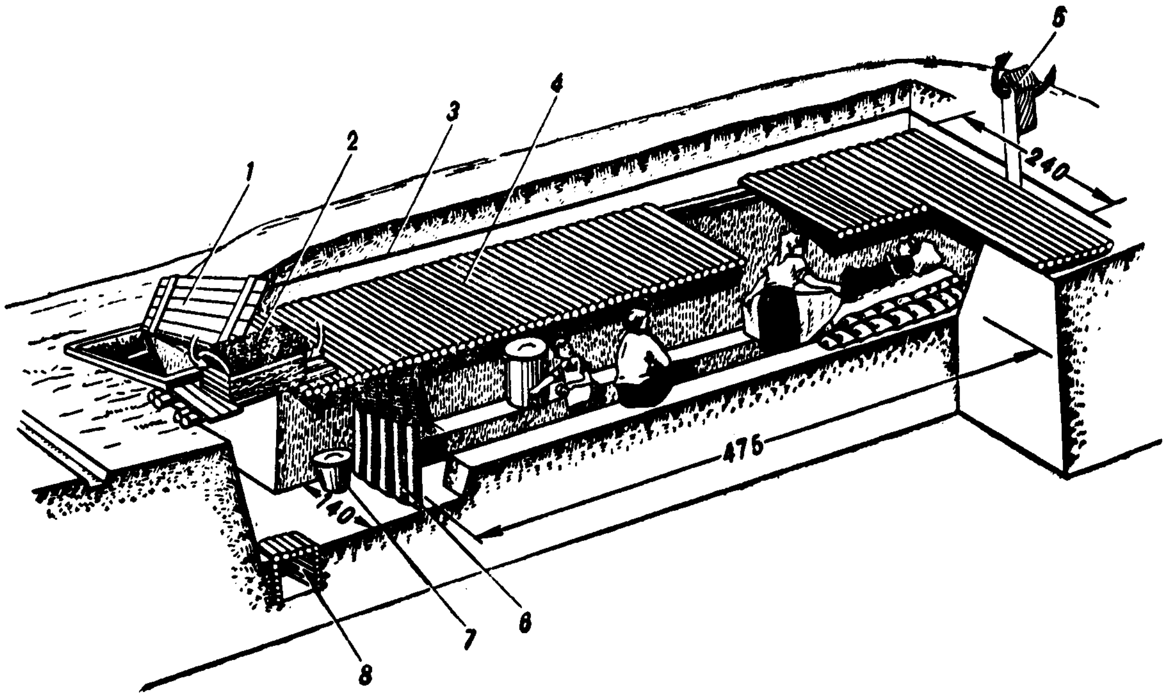


Fig. 6.5. Figure 20. Wood-Earth Shelter without Lining of the Walls for Clay Soils, 10 Occupants: 1 - Trap Door; 2 - Dust Filter with a Straw Packing (hay); 3 - Earth Cover 60-80 cm thick; 4 - Roofing made of Poles; 5 -Exhaust Duct with Damper; 6 - Curtain made of Tightly Woven Cloth; 7 - Removable Container for Wastes; 8 - Water Collecting Sump.

NOTE: Bill of materials is: Rough Lumber, 2.7 cubic meters; Nails, 0.12 kilogram; Wire, 0.64 kilogram; Work Requirement, 90-110 man-hours; Shielding Coefficient, 250-300.

Russian earth-covered expedient fallout shelters are based on military dugouts designed for brief occupancy during a conventional attack. Subsequently, they were improved for fallout protection but were made much less habitable by Soviet civil defense specialists. Apparently these specialists were ignorant of ventilation requirements, and almost certainly they did not field-test small expedient fallout shelters for habitability. Tens of millions of Russians have been taught to build such shelters.

Once any bureaucracy issues dangerously faulty equipment or instructions, it rarely corrects them except under pressure. I have experienced this reluctance even during wartime, when trying to improve faulty combat equipment that was causing American soldiers to lose their lives. Continuing proofs of such bureaucratic reluctance to correct dangerous errors are hundreds of thousands of potentially life-endangering civil defense pamphlets and booklets — especially the several editions of *In Time of Emergency* — kept nationwide in hundreds of communities, primarily for crisis distribution.

Some American official instructions for building expedient shelters have been slowly improved over the decades; the best are given in the June 1985 edition of *Protection in the Nuclear Age,* one of the Federal Emergency Management Agency's widely available free booklets. Yet even in this improved edition no mention is made of the crucial need for forced ventilation during warm weather, nor for expedient, simple means for providing pumped air. Also, in the June 1985 edition of *Protection in the Nuclear Age,* the second crawlway entry/exit of the Above-Ground, Door-Covered Shelter (see Appendix A.4) is replaced by a "4-6" DIA. PIPE FOR VENTILATION," which makes this very small shelter essentially dead-ended and thereby eliminates adequate ventilation in warm weather. With only a 6-inch-diameter air-exhaust opening, not nearly enough air can flow naturally in warm weather through this crowded shelter's room (only about 39 inches wide by 34 inches high). As proved by habitability tests in Florida and elsewhere, a KAP or Directional Fan must be used, even with two crawlway entry/exits.

The essential second crawlway entry/exit of the Aboveground Door-Covered Shelter was eliminated as the result of a recommendation by a contractor for FEMA charged with field testing and evaluating expedient shelters, and improving abbreviated shelter-building instructions. No habitability tests were required. So the contractor concluded in his 1978 report to FEMA that the second entry/exit should be eliminated because "The building of entries is time consuming and with this small a shelter a second entry is really not justified."

In peacetime, bureaucracies of all nations tend to divide up responsibilities between specialists and to promote means by which non-prestigious wartime problems can apparently be solved with the least expense and work.

DIRECTIONAL FANNING TO VENTILATE SHELTERS

The Directional Fanning instructions on the following two pages may save more lives than any other instructions given in this book for a homemakeable survival item. I regret that no one rediscovered this premechanization, simple, yet effective way of manually pumping air until after the original *Nuclear War Survival Skills* was published.

In 1980, Dr. William Olsen, a NASA research engineer long concerned with improving self-help civil defense, rediscovered one kind of Directional Fanning. Since then, with the assistance of able Americans and others, I have designed and tested several types of Directional Fans. I have field-tested and repeatedly improved the instructions to enable average people to quickly learn how to make and use such fans effectively.

The great advantage of Directional Fanning is that almost anyone who is given the field-tested instructions can quickly make and use one of these simple fans. Only very widely available materials are needed. The main disadvantage is that Directional Fanning is a more laborious way to ventilate a shelter than using KAPs, as described in detail in Appendix B.

Americans are not likely to receive Directional Fanning instructions from the Federal Emergency Management Agency. FEMA's predecessors, the Office of Civil Defense and the Defense Civil Preparedness Agency, were unable to get the millions of dollars necessary to buy factory-made KAPs and other manual air pumps to ventilate officially designated fallout shelters, and FEMA has avoided shelter ventilating controversies. No widely available official American publication includes instructions for making and using any expedient air-pumping device.

Thanks to Congressman Ike Skelton, Democrat of Missouri and strong civil defense advocate, in 1981 I was able to demonstrate Directional Fanning to Louis Giuffrida, at that time the Director of FEMA. I gave Directional Fans to the FEMA specialists concerned with shelter ventilation, all of whom have since left FEMA. To date, although Directional Fanning instructions have been reproduced in three private civil defense publications, and some 600 copies of a metric version of the instructions were distributed to British civil defense professionals at the 1984 Annual Study of Civil Defence and Emergency Planning Officers, FEMA has not even evaluated Directional Fanning.

In contrast, in 1981 I gave copies of instructions for both KAPs and Directional Fans to Dr. Yin Zhi-shu, the Director of the People's Republic of China's National Research and Design Institute of Civil Defense — and the next day he started evaluating these simple devices. (At that time I was traveling extensively in China as an official guest, exchanging civil defense information.) Dr. Yin, who heads all Chinese civil defense research and development, went with his top ventilation and shelter design specialists to a furniture factory in Beijing. There I watched workmen quickly build both a large and a small KAP, and also Directional Fans. Then Dr. Yin and his specialists began using their air-velocity meters to measure the volumes of air that these simple devices could pump. On the following days I participated in more ventilation tests using KAPs and Directional Fans in tunnel blast shelters in Beijing and in the port city of Dalien.

While watching these top Chinese civil defense professionals make and test KAPs and Directional Fans, I kept thinking: "This is the way Thomas Edison and Henry Ford would have evaluated simple devices of possible great importance to millions."

The reader is urged to keep the following two pages of Directional Fanning instructions ready for reproduction in a crisis. The sections on the small 2-handled Directional Fan and the large 1-Man Fan will be the most useful to unprepared people. Ventilation by pairs of men using Bedsheet Fans is an effective method for forcing very large volumes of outdoor air through tunnels, corridors and mines with ceilings at least 9 feet high — provided they have two large openings. However, this method requires organization and discipline.

DIRECTIONAL FANNING TO VENTILATE SHELTERS

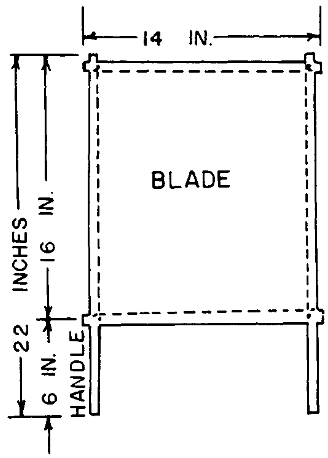
Directional Fanning is the simplest way to force enough outdoor air through typical basement, trench, and other expedient shelters to maintain endurable conditions, even in extremely hot, humid weather.

During a worsening nuclear crisis most unprepared citizens probably will not have the time and/or materials needed to make a KAP or other efficient shelter-ventilating pump — even if they have the instructions. In contrast, tests with average citizens have indicated that if they have instructions for making and using Directional Fans and if there are a few hours of warning time before the attack, then the majority will be able to ventilate all of their expedient shelters, except some of the largest.

The principal disadvantage of Directional Fans is that they are more laborious to operate than are KAPs, that are manually powered, pendulum-like air pumps that conserve energy.

A. DIRECTIONAL FANNING TO VENTILATE AND COOL SMALLER SHELTERS

A **2-Handled** Directional Fan of the size illustrated is less tiring to use and requires less manual dexterity than does a 1-handled fan with the same size blade. With this small 2-handled fan you quite easily can force about 300 cubic feet per minute (300 cfm) of outdoor air through a crowded trench or basement shelter. This is enough air for up to 9 adults crowded into a small shelter in extremely hot, humid weather, and enough for about 100 people in cold weather. By fanning vigorously, 500 to 600 cubic feet per minute have been forced through a small covered-trench shelter.



To make a durable 2-handled fan, first make its frame out of 2 sticks each 14 inches long and 2 sticks each 22 inches long. See sketch. To strengthen the corners, overlap the sticks about one-half inch, as shown.

When using sticks cut from a tree, select ones with diameters of about ¾ inch, and make shallow notches in all 4 sticks before tying together the 4 corners of the blade. If you do not have strong string, use ¾-inch-wide strips of bedsheet cloth, or other strong cloth, slightly twisted.

If using sawed sticks, be sure to use none smaller than ⅜ x ¾ inch in cross section. If you have very small nails or brads, use only one to connect each corner; then tie each corner securely. To prevent possible blistering of hands, wrap cloth around the fan handles, or wear gloves.

To cover the fan's blade, any strong, light fabric, such as bedsheet cloth, serves well. If you are going to sew on the cloth, first cut a 26 x 30-inch piece. Wrap the 30-inch width smoothly crosswise around the frame, after cutting 4 notches in the cloth's corners, so that the tied-together parts of the sticks will not be covered. Pin or tape the cloth to make a smooth blade; finally sew securely. (If waterproof construction adhesive is available, a smaller piece of cloth can be used and the blade can be covered in a very few minutes.)

If time and/or materials are very limited, **make a fan with its blade merely a piece of cloth connecting two 22-inch-long sticks.** This very simple fan is reasonably effective, although tiring to use.

Cardboard covering a blade is likely to become damp and fragile in the humid air of a crowded shelter. Very light sheetmetal makes a good fan blade and requires only 2 sticks. A blade of ¼-inch plywood is too heavy.

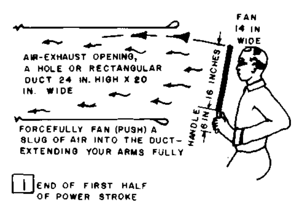
If no sticks are available, a double thickness of heavy, stiff cardboard 22 inches long by 14 inches wide will pump almost as much air if used as a handleless fan. The pieces should be securely tied or taped together. If waterproof tape is available, cover the parts that you will grip with sweaty hands, thus preventing dampening and softening the cardboard.

For maximum ventilation, the air-intake opening of a shelter should be at least as large as its air-exhaust opening. (If the air-exhaust opening of your small shelter is much larger than that shown in the sketches, block part of it off to reduce it to approximately this 24-inch-high by 20-inch-wide size, for more effective use with this fan.) The air should be fanned out of the shelter in the direction in which the air is naturally flowing. For maximum ventilation rate, fan about 40 strokes per minute.

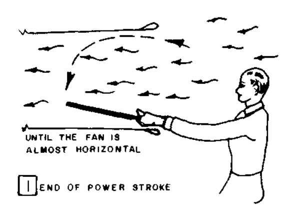
With one or more Directional Fans, air inside a shelter can be distributed effectively and the occupants cooled. Also, if during the time of maximum fallout dose rate the occupants get close together in the most protective part of the shelter, they often will get unbearably hot unless fanned.

To fan air out through an air-exhaust opening, sit facing the opening with your elbows about 4 inches lower than the bottom of the opening. Then count 1, 2, 3 while you:

[1] **Quickly** raise the fan to a vertical position close in front of your face and **immediately** fan (push) a slug of air into the opening — ending the power stroke with your arms fully extended and with the fan almost horizontal and out of the way of air that was "sucked" behind the fan and is still flowing out through the opening.

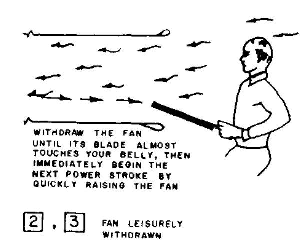


[2], [3] After a slight pause, leisurely withdraw the almost horizontal fan until the bottom of its blade almost touches your stomach — preparatory to the next power stroke.



To increase the flow of air through a shelter, while fanning the occupants:

Have two or more occupants sitting inside the shelter each use a fan of the size described above to fan the air so as to increase its velocity in the direction in which air already is flowing through the shelter. Such Directional Fanning is especially effective in increasing the air flow through small, narrow shelters.



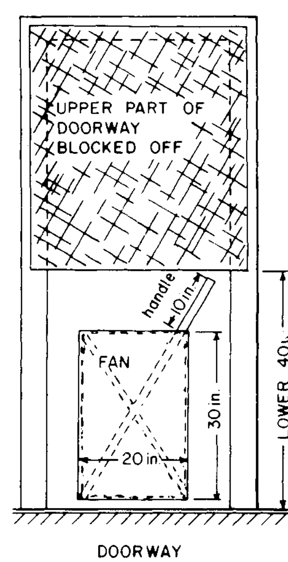
To avoid higher radiation exposures near openings, build an essentially airtight partition across the shelter room, with a 24-inch-high x 20-inch-wide hole in it through which to fan. By fanning through a 24 x 20-inch hole in a cardboard partition built across a doorway inside a U-shaped permanent trench shelter 76 feet long, the air flow was increased by an average of 327 cubic feet per minute.

B. DIRECTIONAL FANNING TO VENTILATE AND COOL LARGER SHELTERS

1. With a Large 1-Man Fan

To ventilate larger basements, big covered trenches, and other large shelters lacking adequate ventilation, use one or more large 1-man fans. See sketch. Note that the 20 x 30-inch fan blade is made like a 2-stick kite, and that the upper end of the longer diagonal stick serves as a 10-inch handle. The model illustrated is made of 2 nominal 1 x 2-inch boards, one 46 inches long and the other 35 inches long. These boards are connected at a point 17½ inches from their lower ends, first with a single clinched nail, and then by being tied securely. The edges of the handle are rounded smooth.

The blade frame is covered on both sides with strong bedsheet cloth, that is wrapped around and secured to the strong cords or wires tied to notches cut in the boards (or sticks) near the 4 corners of the blade. (If cord or wire is not available, 4 2-inch-wide strips of strong cloth, slightly twisted, serve well.)



A durable but laboriously heavy fan can be made in a few minutes using a 20 x 30-inch piece of ¼-inch plywood nailed to a single 46-inch-long, 1 x 2-inch board. Or use a single round stick about 1¼ inches in diameter, flattened on one side.

A fan with its blade made of two sheets of very heavy cardboard tied on both sides of a 1 x 2-inch board is decidedly effective when dry. However, typical cardboard will become soft and worthless in most crowded, long-occupied, humid shelters.

To fan directionally, it is best to stand just outside and to one side of a doorway, so that your body does not obstruct the air flow. Preferably stand opposite and facing the open door, which should be secured open and perpendicular to its doorway. Hold the fan like a golf club and swing it with your arms extended. Then slowly count 1, 2 while you:

[1] Make the power stroke with the fan blade broadside until the end of the stroke, when you quickly turn it 90 degrees.

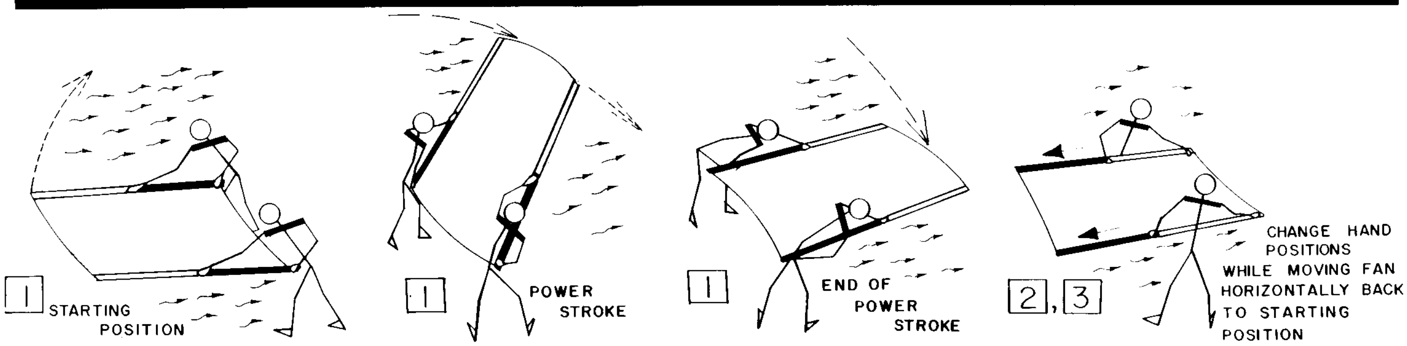
[2] Make the pendulum-like return stroke with the fan blade kept edgewise ("feathered") to the air flow until the end, when you quickly turn it 90 degrees, preparatory to making the next power stroke.

To pump more air, block off the upper part of the doorway with cloth, cardboard, plywood, etc., to prevent air from flowing back in the wrong direction through the upper part of the doorway. See sketch on preceding page.

Whenever practical, directionally fan the air in the same direction that the air is naturally flowing through the shelter. More air usually can be pumped through a shelter if the fan is used to force air out through the air-exhaust opening. This reduces the air pressure inside the shelter and causes fresh outdoor air to be "sucked" into the shelter through the air-intake doorway, or through other large air-intake openings. Thus with one fan 1,000 cubic feet per minute can be pumped through a fully occupied shelter. This is enough outdoor air — if it is properly distributed within the shelter — to maintain tolerable conditions for weeks for 25 occupants during extremely hot weather, and for up to about 300 occupants during cold weather.

To ventilate and cool a room having only one doorway and no other opening, do not block off any part of the doorway. If air is fanned into such a room through the lower part of its completely open doorway, then air will flow back out of the room through the upper part of the doorway. However, this pumps much less air than when a separate, large air-exhaust opening is provided.

To increase the flow of outdoor air through a tunnel-shelter, several fanners equally spaced along its length should each fan in the direction of the natural air flow. This procedure was first proved practical during a 1981 ventilation test that Cresson H. Kearny participated in with Chinese civil defense officials in the port city of Dalien. In this test 5 fanners, each with a fan of approximately the size illustrated, forced air from the outdoors through a 395-foot section between two opened entrances of a typical Chinese tunnel-shelter. The air flow was increased from a natural flow of 290 cubic feet per minute to 3,680 cubic feet per minute. The 5 excellent Chinese fans each had a blade made of a piece of 3 mm (approx. ⅛ inch) plywood nailed to a single board.



2. With a Bedsheet Fan

Use a 2-man Bedsheet Fan to force thousands of cubic feet per minute of outdoor air through a tunnel or long corridor having at least a 9-foot ceiling and a large opening at each end. The most practical design tested was made from a strong double bedsheet cut down to 6-foot width, with the wide hem at its head-end left unchanged and with a similar-sized hem sewn in its opposite end, to give a finished length of 6 feet. A 6-foot-long, nominal 1 x 2-inch board (or an approximately 1½ inch diameter stick) was secured inside each end hem of various models with waterproof construction adhesive, or with tacks, or by tying. Before a board was inserted, its edges were rounded. Round sticks were smoothed.

Two persons preparing to use a Bedsheet Fan (see sketch) should stand facing each other, at right angles to the desired direction of air flow, with the cloth extended horizontally between them. Each fanner should grip his stick with one hand near its "downwind" end and with his other hand near its center.

A pair of Directional Fanners get ready to make a power stroke by leaning in the upwind direction, as illustrated. Then the pair of fanners should count 1, 2, 3 while they:

[1] Make the power stroke by rapidly sweeping their sticks and the attached cloth in an arc, until they are leaning in the downwind direction and the sticks and cloth are again horizontal. See sketch.

[2], [3] Hold the sticks and cloth horizontal (to permit air that was "sucked" behind the cloth to continue flowing in the desired direction) while leisurely moving the Bedsheet Fan back to the starting position. During this move the fanners change hands, as illustrated. (Note that what was the upper side of the fan at the beginning of the power stroke now has become the lower side.)

Two men thus fanning vigorously produced a net air flow of 5,500 cubic feet per minute through an empty school corridor that is 8 feet wide, has a 9-foot ceiling, and is 194 feet long. The doors at both ends were open. To adequately ventilate and cool people crowded into a long tunnel in hot weather, a pair of Bedsheet Fanners should be positioned about every 100 feet along its length.

The practicality of using Bedsheet Fans to ventilate some very large mines or caves having 2 or more large openings was proved by tests with members of the Citizens Preparedness Group of Greater Kansas City. These tests were conducted in 1982 near Kansas City in a huge limestone mine that has a ceiling averaging about 17 feet high, corridors about 35 feet wide, columns of unexcavated rock about 15 feet square, and over 1,000,000 square feet of level, dry floor space. The air inside is "dead", remarkably still, because the only openings are two truck-sized portals on one side of the mine. Five pairs of Bedsheet Fanners, spaced about 75 feet apart down a corridor, after fanning for several minutes produced a measured air flow of approximately 100,000 cubic feet per minute through this part of this corridor!

With many more pairs of Bedsheet Fanners working, enough air for at least 10,000 occupants could be "sucked" into this mine through one of its 17 x 20-foot portals, fanned down a corridor to the far "dead end" of the mine, then fanned through a cross corridor, and finally fanned back out through the corridor that has the second truck-sized portal at its outer end.

A pair of pre-mechanization coal miners produced a directed airflow by holding a piece of canvas **vertically** between them while they quickly walked a short ways in the direction of the desired airflow; they walked back with the canvas held **horizontally** between them. Then they repeated.

C. ADDITIONAL ADVANTAGES OF DIRECTIONAL FANS

1. No installation is needed, thus saving working time and materials for making habitable shelters hurriedly built or upgraded during a crisis.

2. Directional Fans enable shelter occupants to quickly reverse the direction of air flow through their shelter when outdoor wind changes cause the direction of natural air flow to be reversed.

3. Four or more Directional Fans when used to circulate air within a shelter room can serve like air ducts, while simultaneously fanning occupants.

4. Directional Fans are very unlikely to be damaged by blast effects severe enough to wreck bladed fans or other fixed ventilation devices placed at or near air-intake or air-exhaust openings, but not severe enough to injure shelter occupants.

Chapter 17
Permanent Family Fallout Shelters for Dual Use

THE NEED

Having a permanent, ready-to-use, well supplied fallout shelter would greatly improve millions of American families' chances of surviving a nuclear attack. Dual use family shelters — shelters that also are useful in peacetime — are the ones that Americans are most likely to build in normal peacetime and to maintain for years in good condition for use in a nuclear war.

The longer nuclear peace lasts, the more difficult it will be, even during a recognized crisis, to believe that the unthinkable war is about to strike us and that we should build expedient shelters and immediately take other protective actions. The lifesaving potential of permanent, ready-to-use family shelters will increase with the years.

Americans who decide to build permanent shelters need better instructions than can be obtained from official sources or from most contractors. This chapter brings together fallout shelter requirements, based on shelters and shelter components that have been built and tested in several states and nations. The emphasis is on permanent fallout shelters that many Americans can build for themselves. The author believes that millions of Americans can build good permanent fallout shelters or have local contractors build them — if they learn the shelter requirements outlined in the following sections of this chapter and the facts about nuclear weapon effects and protective measures given in preceding chapters. Builders can use their skills and available local resources to construct permanent, dependable fallout shelters at affordable cost.

Requirements for a permanent, dual-use family fallout shelter follow.

A HIGH PROTECTION FACTOR, AT AFFORDABLE COST

A permanent fallout shelter should be built — and can easily be built — to have a high enough protection factor to prevent its occupants from receiving fatal or incapacitating radiation doses, and also from receiving doses large enough to seriously worsen their risks of developing cancer in the years following an attack. Shelters with a protection factor of 40 (PF 40) meet the minimum standard of protection for public shelters throughout the United States, and permanent family fallout shelters described in official pamphlets provide at least PF 40 protection. In almost all fallout areas, PF-40 shelters would prevent occupants from receiving fatal or incapacitating radiation doses while inside these shelters. However, in areas of heavy fallout the occupants of PF-40 shelters could receive radiation doses large enough to significantly contribute to the risk of contracting cancer years later. Furthermore, the larger the dose you receive while in a shelter, the smaller the dose you can receive after you leave shelter without being incapacitated or killed by your total dose.

If you build a permanent shelter, you would be foolish to build a shelter with a PF of only 40 when additional protection is so easy to obtain. By making a shelter with a 6-inch-thick concrete roof covered by 30 inches of shielding earth, and with other easily attained design features shown in Figs. 17.1 and 17.2, you can have a shelter with a protection factor of about 1000. (An occupant of a PF 1000 shelter will receive a radiation dose only 1/1000th as large as he would receive if he were standing outside in an open field during the same time interval.) To attain PF 1000 protection near the inner door of the illustrated

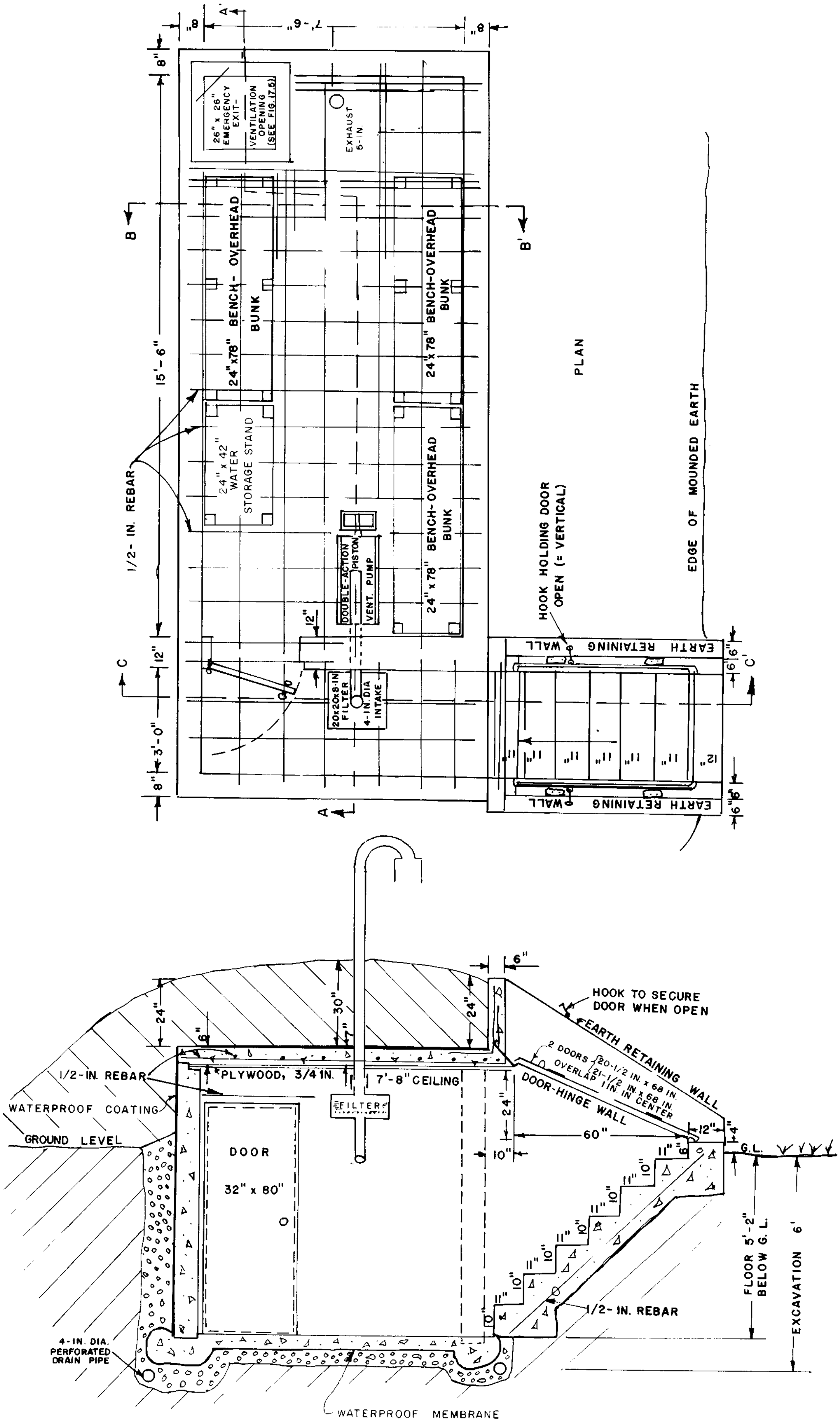
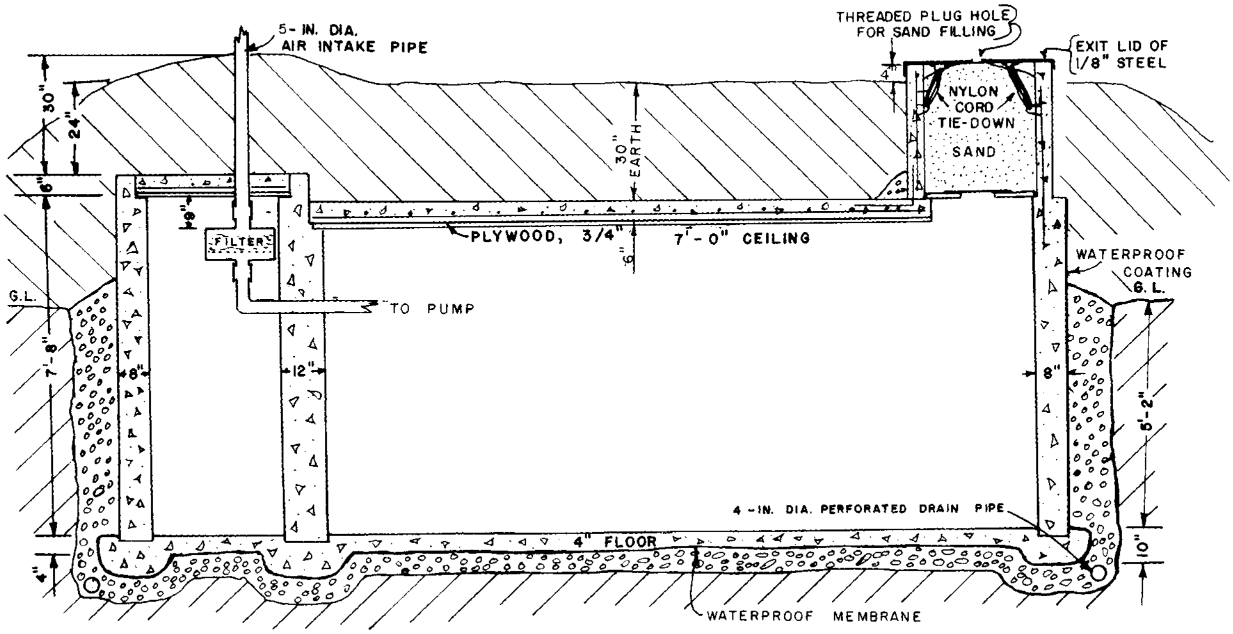
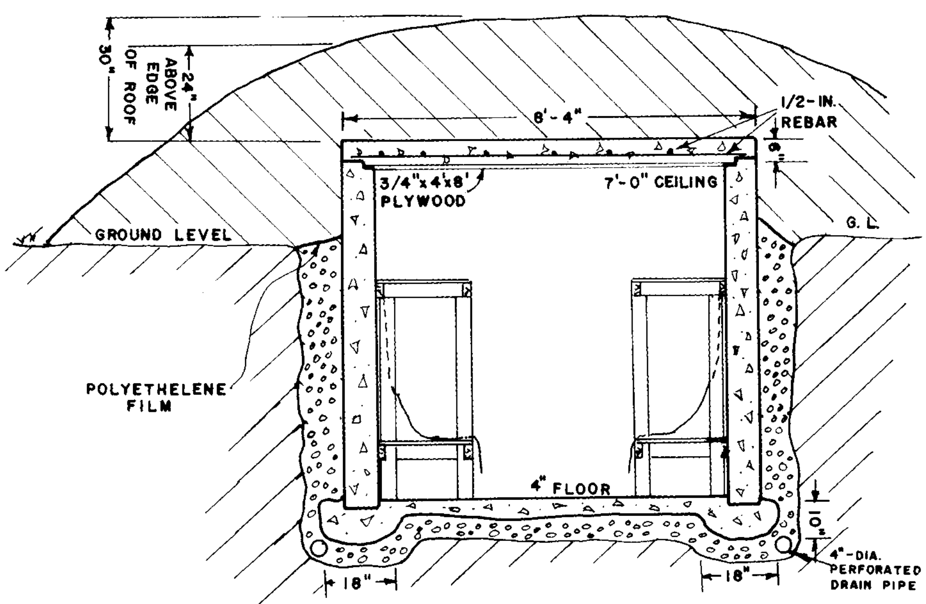


Fig. 17.1. Permanent Family Fallout Shelter for Dual Use.



SECTION A-A'



SECTION B-B'

Fig. 17.2. Permanent Family Fallout Shelter for Dual Use.

shelter, its occupants must place containers full of water and/or other good shielding material against the door. They can do this easily and quickly if the shelter is supplied with filled water containers such as described in the Water section of this chapter.

The illustrated shelter room has 106 square feet of floor space — room enough for 5 adults and the survival essentials they will need for long occupancy, if shelter furnishings like those described in this chapter are provided. For each additional occupant, increase this shelter's length by 2 feet. To increase room size, increase length and not width. This retains maximum roof strength at minimum cost.

Note in Figs. 17.1 and 17.2 the 12-inch-thick concrete wall between the landing at the foot of the stairs and the end of the shelter room. Only a very small fraction of the radiation coming through the outer doors and down the stairs will make the 90 degree turn through the inner door, and most of this radiation will not strike shelter occupants if they place containers filled with water and other shielding material against the door.

Also note the homemakeable, low cost Double-Action Piston Pump and filter, shown in Fig. 17.1, that even in a heat wave will supply adequate air through the 5-inch-diameter air-intake pipe — all described in Appendix E.

Few survival-minded Americans, before a recognized international crisis arises, either can afford or believe that they can afford to build a permanent family fallout shelter costing around $10,000 in 1987. A small reinforced concrete, below-ground shelter of the type specified in official Federal Emergency Management Agency pamphlets costs about $100 per square foot of floor space, if built by a contractor in a typical suburban area. Those with the needed skills and time can save about half of this cost by doing their own work. Also, at many building sites where gravity drainage of the earth around a shelter's walls can be assured and hydrostatic earth pressure against the walls thus prevented, no steel reinforcement in the poured concrete or concrete block walls is needed — unless required by the local building code.

Caution: Steel reinforcement in the walls and floor is needed in some clay soils that swell when wet and exert sufficient inward and upward pressure to crack unreinforced walls and floor slabs. Consult local builders who have learned from experience whether wall and floor reinforcement is needed in the type of soil where you plan to build. If needed, a grid of ½-inch rebars, spaced at 12 inches, usually is adequate. To save money on steel reinforcement, check prices in salvage yards for used rebars and substitute reinforcing materials such as junked cable and small pipes.

How to safely pour a shelter's concrete roof slab without using a contractor's usual forms and equipment is indicated by Figs. 17.1 and 17.2. These drawings show 8-ft.-long sheets of ¾-inch plywood supported at their ends on shelter walls 7 feet-6 inches apart. Preparatory to pouring the concrete, the plywood sheets should be supported along the centerline of the shelter by 4"x4"s and other lumber, which can be used later to build seats and overhead bunks. Plywood left on the ceiling reduces condensation and heating problems in cold weather, but increases the volume of outdoor air that must be pumped through the shelter to maintain tolerable temperatures when it is occupied in hot weather. This was clearly demonstrated in the summer of 1963 when the author used SIMOCS (simulated occupants that produce heat and water vapor like people) to determine the habitability of a six-roomlet below ground group shelter, with a reinforced concrete roof that had been built in this manner by six New Jersey farm families. They had left ordinary ¾-inch exterior plywood on the ceiling. Because the hollow concrete wall-blocks and the well drained gravel under the floor also kept heat from escaping into the surrounding soil, and because only natural ventilation was provided, the temperature/humidity became dangerously high within a few hours.

Insulating a shelter's walls and ceiling can be disadvantageous, because insulation makes unavailable the "heat sink" of the shelter and its surrounding earth. In hot weather insulation reduces the time during which ventilation can be stopped or restricted without disastrously overheating the occupants.

Today, for such a shelter it would be better to use pressure-treated, rot-proof plywood and lumber, approved by leading building codes. For information, write to the American Plywood Association, P.O. Box 11700, Tacoma, WA 98411, enquiring about rot-proof plywood, dimensional lumber, and other material used in building the All-Weather Wood Foundation. Most lumber yards will obtain treated plywood on order, and sell it for about 50% more than ordinary exterior grade plywood.

Big savings in shelter construction costs are made by using salvaged and/or used materials. Manufacturers of pre-cast reinforced concrete beams and floor sections often sell rejects for very little. Most salvage yards have steel beams and other material that make excellent roofing for earth-covered shelters. (Shortly before the Cuban Missile Crisis, when living near New York, I built for myself at modest cost a very small shelter on a well drained hillside. I made it almost entirely of steel channels bought and cut to order at a salvage yard.) Used cylindrical steel tanks with closed ends often make good low-cost permanent shelters. One of the best low-cost family shelters that I ever went into was on a hillside overlooking San Francisco Bay. It was made of a salvaged steel brewing tank that had been installed after a vertical cylindrical entrance with a door had been welded on it. The tank's exterior had been protected with a bituminous coating. Its survival-minded owner was a brilliant Hungarian refugee who, as a boy, had survived in a deep wine cellar throughout the Russian siege and shelling of Budapest. Nothing equals war experience to teach the lifesaving value of shelters.

MINIMIZATION OF FIRE AND CARBON MONOXIDE DANGERS

Many shelter designers and builders do not realize the probable extent of fires after a major nuclear attack. Nor do the big majority of them provide shelters built under or close to a house with adequate protection against the entry of deadly amounts of carbon monoxide if the house burns. Although the areas of fires resulting from a nuclear explosion generally will be about as extensive as the areas of significant blast damage,[6] on a clear day a house up to about 8 miles from ground zero can be ignited by the thermal pulse of a 1-megaton airburst.[6] Figure 7.2 in Chapter 7 is a photograph of a car set on fire by a nuclear explosion so far away that the car was not even dented by the blast. This photograph indicates how a thermal pulse can go through window glass and ignite curtains, upholstery, or dry paper, even if flammable material outdoors is too damp to be ignited. Furthermore, fires from any cause can spread, especially in fallout areas following a nuclear attack when firefighters may be unable or unwilling to expose themselves outdoors to radiation.

Good protection against carbon monoxide is provided by a permanent earth-covered shelter, built with its entry outdoors and well separated from a house and other flammable structures, and constructed so that it can be closed gas-tight. Both the air-intake and the air-exhaust pipes should be installed so that they can be quickly closed air-tight, as with screw-on fittings. Such closures should be kept well greased and securely attached close to where they would be used. If a shelter's entry is through a passageway from a house, a gasketted steel firedoor, insulated on the shelter side, should be installed near the house end of the passageway. The shelter should be further protected by a second gas-tight door, to prevent the entry of carbon monoxide and smoke if heat from the burning house destroys the gasket on the firedoor. If special firedoor gaskets are not available, rubber weatherstripping will serve. To lessen the risk of carbon monoxide being pumped into the shelter if the house burns and air must be pumped into the shelter while the fire still is smoldering, the air-intake and pump should be at the far end of the shelter, and the air-exhaust pipe and emergency exit should be near the passageway from the house.

Be sure to seal electrical conduits leading from a basement to a connected shelter, so that if the house burns carbon monoxide can not flow through the conduits into the shelter when fresh outdoor air is not being pumped into the shelter. The author, while conducting ventilation and habitability tests of an earth-covered blast shelter connected through a tunnel to a house's basement, observed air flowing out through unsealed conduits, the reverse of such a possible life-endangering flow of carbon monoxide. When the shelter was being maintained at a slight overpressure by cranking its blower to pump in outdoor air, a little air flowed through the unsealed conduit into the basement.

For ways to minimize carbon monoxide dangers arising from cooking, heating, lighting, and smoking, see following sections in this chapter.

Remember that air contaminated with only 0.16% carbon monoxide can kill you in 2 to 3 hours, and 0.04% carbon monoxide causes frontal headaches and nausea in 2 to 3 hours. The Navy sets its safe allowable carbon monoxide concentration in air at 0.01%. (*Shelter Habitability Studies — The Effect of Oxygen Depletion and Fire Gasses on Occupants of Shelters,* by J. S. Muraoka, Report NCEL-TR-144, July 1961.)

PREVENTION OF CRACKS AND WET SHELTER PROBLEMS

If wet basements are a problem in your locality, below ground shelters are likely to be wet and unsatisfactory unless appropriate preventative measures are taken during their design and construction. When making plans, you should consult local builders of satisfactory basements. You also should question persons who at various times of the year have observed excavations, holes, and/or basements in your immediate vicinity, or have noted seasonal swampy places or springs.

The most difficult type of shelter to keep dry for decades is one that is wholly or partially below the water table for part or all of the year. Concrete is not completely watertight. Waterproof coatings and coverings often are damaged during construction, or deteriorate with age.

Shelter walls sometimes crack due to settling and earth movements. Metal shelters usually develop small leaks long before they become dangerously weakened.

A 100-occupant, below ground shelter, built in 1984 near Dallas, Texas as a prototype blast shelter for industrial workers, was flooded when the water table rose. The poorly sealed opening of this shelter's emergency exit was below ground level, and after heavy rains was below the water table. A prudently designed shelter has the top of its emergency exit slightly above the surface of the surrounding earth, as illustrated in Fig. 17.2. All underground electric conduits leading down into a shelter must be well sealed to prevent entry of water.

To prevent a wholly or partially below-water-table shelter from becoming wet inside sooner or later, it should have a sump and an automatic sump pump to discharge water to the ground outside. If at any time you find that the sump pump is discharging an appreciable amount of water, you may have a serious wet-shelter problem if electric power fails after an attack.

A manually operated bilge pump and a sufficiently long discharge hose can be bought for about $20.00 from marine supply mail order firms, including West Marine Products, Box 5189, Santa Cruz, California 95063, and Defender Industries, Inc., P.O. Box 820, New Rochelle, New York 10802-0820. (Long established marine supply companies also are good sources of use-proven chemical toilets, first aid kits, lights, rope, etc.)

Shelter roof surfaces should be gently sloped, no matter how good a waterproof coating is to be applied. By making a concrete shelter roof as little as 1 inch thicker along its centerline than along its sides, so that it slopes to both sides, the prospects are improved for having an earth-covered coated roof that will not leak for decades.

Figures 17.1 and 17.2 illustrate the following ways to prevent having a wet shelter:

* Put a layer of gravel or crushed rock in the bottom of the excavation, and install perforated drainage pipes if gravity drainage is practical.

* Cover the gravel or crushed rock in the floor area with a plastic vapor barrier before pouring a concrete floor.

* Coat the outer surfaces of roof and walls with bituminous waterproofing or other coating that has proved to be most effective in your locality.

* Backfill with gravel or crushed rock against the walls, to keep the soil from possibly becoming saturated. Saturated soil exerts hydrostatic pressure against walls, and may crack them and cause them to leak. In some areas it is more economical to cover a shelter's coated walls with a subsurface drainage matting (such as Enkadrain, manufactured and sold by BASF Corporation, Fibers Division, Enka, North Carolina 28728). This will eliminate the costs of backfilling with gravel or crushed rock.

NON-FLOATABLE SHELTERS

In most localities the water table usually is below the depth of excavation needed to build or install a belowground shelter. In some areas, however, after rainy periods the water table may rise until it is only a foot or two below the surface. Then a watertight shelter may float upward through the surrounding saturated soil, unless its weight plus the weight of its covering earth is sufficient to withstand its buoyancy. (In many places swimming pools are kept full to prevent them from being cracked by uneven buoyant forces if the water table rises.)

Dramatic examples of floating shelters were steel blast shelters, guaranteed by contractors to be watertight, that were installed under the lawns of some Houston, Texas homes shortly after the Cuban Missile Crisis. When the water table rose after heavy rains, these shelters came up to the surface like giant mushrooms, to the frustrated dismay of their owners and the satisfaction of anti-defense newspaper feature writers.

The most expensive permanent family fallout shelter described in a Federal Emergency Management Agency free handout (pamphlet H-12-1) is floatable. It is designed to be built of reinforced concrete covered by a flagstone patio only about 3 inches above the ground. Its 6-inch-thick concrete roof is covered by a total thickness of only 6 inches of sand and flagstone. Like the rest of FEMA's permanent shelters, no prototype of this approximately PF-40 shelter was built, nor is there any record of anyone actually having built this shelter. In contrast, the belowground shelter illustrated by Figs. 17.1 and 17.2 would not float even if it did not have assured gravity drainage of the surrounding soil through the perforated drain pipes in the gravel on which it rests, because this shelter is weighted down by the thick earth berm on its roof.

ADEQUATE, DEPENDABLE VENTILATION/COOLING

Basic facts that you need to provide adequate, dependable ventilation for a small or medium sized shelter are given in Chapter 6, **Ventilation and Cooling of Shelters.** A good permanent shelter has two ventilation systems:

- The **primary ventilation system** of a small permanent shelter should utilize a manually operated centrifugal blower, or a homemade Plywood Double-Action Piston Pump. (See Appendix E.) A satisfactory air pump must be capable of supplying adequate outdoor air through an air-intake pipe, a filter, and an air-exhaust pipe. (See Figs. 17.1 and 17.2.) "Adequate outdoor air" for a small shelter means at least 15 cubic feet per minute per occupant for the cooler parts of the United States, and at least 30 cfm per occupant in most of the country. Most permanent shelters have centrifugal blowers that can not deliver an adequate volume of air in hot weather for each planned occupant.

For a medium sized permanent shelter, installing two or more manually powered air pumps is both more dependable and more economical than providing an emergency generator and its engine to supply power to an electric blower. The Swiss, who have made the world's best and most expensive per capita preparations to survive a war, use one or more hand-cranked centrifugal blowers to ventilate most of their shelters.

- The **multi-week and/or emergency ventilation system** of a permanent shelter that has an emergency exit should depend on a homemade KAP, made before a crisis and kept ready to use. (See Appendix B, **How to Make and Use a Homemade Shelter-Ventilating Pump, the KAP.)** By opening both the entrance and the emergency exit, the shelter is provided with two large, low-resistance openings through which a KAP can pump large volumes of air with minimum work.

Warning: Keep screen doors and/or screen panels ready to protect all openings against the swarms of flies and mosquitoes likely to become dangerous pests in fallout areas. Use your KAP to pump adequate air through screens. Insect screens greatly reduce natural ventilation, as the author first noted in Calcutta while a bed-ridden patient in a stifling hot ward of a hastily constructed Army hospital. Because there were no fans or blowers to pump in outdoor air or circulate the air inside, window screens were opened in the daytime when malaria mosquitoes were not flying. The doctors correctly concluded that the temperature reduction when the screens were opened helped the patients more than they were endangered by the entering filthy flies. Adequate ventilation is more important than protection from flies, but with a KAP and insect screens you can have both. Flies, mosquitoes, and other insects can be killed very effectively by occasionally spraying or painting screens and other alighting surfaces with water solutions of insecticides containing permithin and sold in many farm stores.

ADVICE ON VENTILATION OPENINGS AND FITTINGS

- Install ventilation pipes large enough to reduce resistance to airflow, thus increasing the volume of air that the shelter's pump can deliver. A shelter with a 200-cfm pump (such as the homemakeable Plywood Double-Action Piston Pump described in Appendix E) should have 5-inch galvanized steel pipe. The pumps that are installed in most family shelters deliver only about 100 cfm or less. Four-inch pipe is adequate for use with pumps this small, provided that the pipes have no more than two right-angle turns below each gooseneck. (A 90-degree L gives about as much resistance to airflow as 12 feet of straight pipe.)

- Make and install a gooseneck with its mouth about twice the diameter of the pipe, as indicated in Fig. 17.1. The purpose of such a gooseneck is to prevent more of the larger descending fallout particles from being pumped or blown into the shelter. For example, if 200 cfm of air is being pumped into a shelter through a gooseneck of 5-inch-diameter pipe with its mouth also 5 inches in diameter, the velocity of the air up into the mouth of the gooseneck is about 1,440 feet per minute, and sand-like spherical particles smaller than approximately 500 microns in diameter also are "sucked" up.[6] But if the 5-inch gooseneck's mouth is 10 inches across, then the upward air velocity is reduced to about 360 feet per minute, and only particles smaller than approximately 180 microns across are "sucked" up. Particles in the 180 to 500 micron-diameter range are relatively large and fall to earth in about 40 to 70 minutes from 35,000 feet, the base of the mushroom cloud of a 1-megaton explosion. (See Fig. 6.4.) These particles are very dangerous because their radioactivity has had little time to decay, and should be kept out of a shelter's ventilation system. Furthermore, large particles retained in a shelter's filter restrict airflow sooner than do small ones. (If an appropriately curved piece of 5-inch steel pipe cannot be found in a salvage yard or elsewhere, a good welder can use 5-inch steel pipe to make a substitute gooseneck with two 90-degree turns.)

- Do not use air intake hoods on a permanent shelter's pipes, because hoods are not as effective as goosenecks in preventing fallout particles from entering ventilation pipes. Also, pumping a given volume of air through a hood is more work than pumping the same volume through a gooseneck with equal cross-sectional areas.

- Never install any screen inside a gooseneck or air intake hood, because spider webs and the debris that sticks to webs will greatly reduce airflow. The author saw a gooseneck with a blast valve built inside it; spider webs and attached trash on this blast valve had consequentially reduced the volume of air that this shelter's pump could deliver. Of course a screen is much more easily obstructed than a blast valve. Yet FEMA's widely distributed pamphlets on a permanent Home Fallout Shelter (H-12-1) and on a Home Blast Shelter (H-12-3) continue in successive editions to give detailed instructions for making an air intake hood with a screen soldered inside it. But these shelters that never have been built have much more serious weaknesses, including the likelihood that the aboveground parts of the ventilation pipes of the blast shelter would be bent over or broken off by blast-wind-hurled parts of buildings and trees, even in suburbia. (350 mph is the maximum velocity of the blast wind where the blast overpressure is 15 psi from a 1-megaton air burst.[6] The ventilation openings of the blast-tested expedient blast shelters described in Appendix D are much more likely to remain serviceable after being subjected to severe blast effects, because blast-protector logs are placed around their openings, that are only a few inches above ground level.)

PREVENTION AND CONTROL OF CONDENSATION

A shelter can be watertight, yet at certain seasons of the year its walls, ceiling, and floor can be dripping wet with water condensed from entering outdoor air. (This is a serious problem, except in arid parts of the West.) During the winter months a shelter and its surrounding earth get cold; then especially on some spring days the dew point of entering outdoor air is higher than the temperature of the shelter's interior surfaces. As a result, condensation occurs on those surfaces that are cooler than the dew point of the pumped-through air.

The most dramatic example that I have observed of the seriousness of this condensation problem was the dripping ceiling and wet walls of a reinforced-concrete, family-sized shelter that I inspected on an early spring day at the Civil Defence College in Yorkshire, England.

Such condensation also can occur in aboveground structures. Before World War II I had a 600-year-old bedroom in Queen's College, Oxford University. My bedroom's outer wall was made of solid limestone blocks about 15 inches thick, simply plastered and painted on the inside. On some spring days moisture condensed on the inside of the cold outer wall, ran down, and collected in little puddles on the floor. The occasional small coal fire in my adjacent study was barely sufficient to gradually evaporate the water and reduce my bedroom's humidity enough to prevent mold from forming. This often-repeated occurrence proves the inadequacy of merely keeping an electric light turned on for heat to prevent condensation inside an uninsulated shelter built in a cool, frequently humid locality.

Condensation and resultant 100 percent humid air can rust and eat away most steel pipes. Ventilation pipes should be made of galvanized steel or other materials that are undamaged by seasonal condensation and 100 percent humidity. In Connecticut I saw shelter ventilation pipes made of steel protected with two coats of marine paint; they were badly rusted only two years after installation.

Operating a dehumidifier with automatic controls is the most practical way for most people to prevent condensation and other dampness problems in a shelter during peacetime. Almost all of the Chinese shelters that I inspected in six cities are dual-use shelters and typically are equipped with large dehumidifiers. A small dehumidifier adequate for a family shelter can be bought from a dependable mail order company, such as Sears, for about $250 in 1987.

To save floor space and facilitate removal of water, a dehumidifier should be installed near a shelter's ceiling. Then water from the dehumidifier can be disposed of most easily through a pipe or tube providing gravity drainage, best to the outdoors, second best to the sewer. (After a nuclear attack the sewer system may become clogged and sewage may back up and flow into a belowground room having pipes that normally discharge into the sewer, and that lack check valves.) If the above mentioned ways of removing water are not possible, a sump and an automatic sump pump discharging water to the ground outdoors can solve the peacetime water disposal problem.

After an attack, electric power can be expected to fail and shelter humidity will have to be controlled as much as possible by ventilation with outdoor air. A simple way to learn when to ventilate a shelter to dry it was described in a Russian article on shelter management: Keep several small cans of water in the shelter. They will be at about the same temperature as the shelter walls when the shelter is closed and is not being ventilated. If a filled can is exposed to outdoor air for about 10 minutes and moisture condenses on it (as a glass filled with an iced drink "sweats" on a humid summer day), do not ventilate the shelter. If no moisture condenses on the can, ventilate.

A WALK-IN ENTRANCE

Only a small fraction of permanent family shelters without a walk-in entrance have been kept in good condition for many years. Permanent family shelters with vertical or crawl-in entrances are found so inconvenient that the big majority of owners do not use them even for rotated food storage. In normal peacetime, most well informed Americans concerned with protecting their families conclude that only a shelter skillfully designed for dual use justifies the cost of building and maintaining it. Significantly, Chinese civil defense has come to the same conclusion regarding Chinese permanent public shelters: those that have been built, and that still are being built, are almost all useful both in peacetime and in wartime.

If a family can use its shelter without having to go outside and be exposed to rain, snow, cold, or night problems, its dual use shelter will be a more valuable peacetime asset than a shelter not directly connected to the house. Furthermore, a directly connected shelter can be entered more quickly in a crisis, and probably will reduce post-attack exposures to fallout radiation received by persons carrying things into the shelter, or by those moving about post-attack to protect the home. The main disadvantages of a directly connected shelter are that it usually provides poorer protection against heat, smoke and carbon monoxide if the house burns and that it is more expensive to build than an earth-covered shelter with an outdoor walk-in entrance, such as the one illustrated in Figs. 17.1 and 17.2.

AN EMERGENCY EXIT THAT ALSO PROVIDES A SECOND LARGE VENTILATION OPENING

Having an emergency exit in a fallout shelter is not as important as having one in a blast shelter, unless the fallout shelter is under or connected to a building. (Since buildings are likely to burn, it is important to have a means of escape.) However, an emergency exit makes any shelter more practical to live in than a shelter with only one large opening — especially in a heavy fallout area where it may be necessary to stay inside most of the time for weeks or months. Occupants of a shelter with only one large opening will not have adequate natural ventilation and will have to keep laboriously pumping air — at least intermittently — through the air-supply pipes to maintain liveable temperature and/or humidity conditions.

By opening both a shelter's entrance and its emergency exit, and taking measures to prevent the entry of rain, snow, and all but the smallest fallout particles (see Appendix F), natural ventilation will be adequate most of the time, except in hot, calm weather. With two large openings, a homemade KAP (see Appendix B) can be used to pump enough outdoor air through the shelter, with much less work than is required to pump less air with a relatively high-pressure pump through typical ventilation pipes.

A DEPENDABLE, HIGH-PROTECTION-FACTOR EMERGENCY EXIT

Occupants of a shelter with a dependable emergency exit will have less fear of being trapped if the main entry is blocked. If they open the exit, they also will be able to ventilate the shelter with natural ventilation through the entry and the exit, or with forced ventilation by operating a KAP.

To provide excellent radiation protection, a typical high-PF emergency exit is filled with sand. Such an exit has a bolted-on steel plate on its bottom inside the shelter, and an easily cut, waterproof, plastic-film covering over its top, which is a few inches below ground level. Obvious disadvantages of this typical sand-filled emergency exit include the difficulty of safely removing the bottom plate while sand is pressing down on it, and the impossibility of cutting the plastic film over the top of the exit without having fallout-contaminated earth fall on the person who does the cutting, and into the shelter room. Furthermore, if the earth covering the top of an emergency exit is frozen, occupants may be unable to break through it and get out.

An improved design of sand-filled emergency exit was conceived by Dr. Conrad V. Chester of Oak Ridge National Laboratory and in 1986 was further improved, built, and tested in a full-scale model by the author. As shown in Fig. 17.2, the sand in this 26 x 26-inch square vertical exit was supported by a piece of 3/4-inch exterior plywood, that should be of the previously mentioned rot-proof type, pressure impregnated with wood preservative.

In the center of this 25½ x 25½-inch plywood sand-support was an 8-inch-diameter hole covered with two thicknesses of strong nylon cloth.

The double thickness of cloth was firmly attached to the plywood by being folded over four 3/16-inch galvanized steel rods, that were stapled to the plywood with galvanized poultry-netting staples. (See Figs. 17.2 and 17.3.) The nylon cloth covering the hole can be easily and quickly cut with a knife, permitting sand to fall harmlessly into the shelter room.

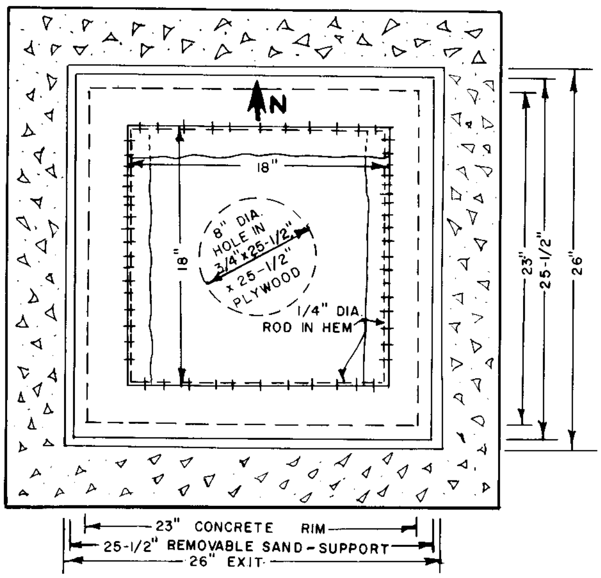


Fig. 17.3. Plan of Vertical Emergency Exit, Before Filling with Sand.

As shown in Figs. 17.2 and 17.3, the square 26 x 26-inch plywood sand-support rests on a 1½-inch-wide rim or ledge around the 23 x 23-inch square hole in the shelter's reinforced concrete roof slab. After a shelter occupant has cut out the nylon cloth covering the hole and all but about 30 lbs of sand has fallen or been pushed by his hand down into the shelter room, he can tilt the plywood sand-support up into a vertical position, and then turn it 45 degrees. The 26-inch width of the sand-support permits it to be easily lifted down through the 32.5-inch-long diagonal of the 23 x 23-inch square hole in the shelter's roof slab.

Note the North-pointing arrow on the plywood sand-support shown in Fig. 17.3. Because the exit of this shelter was not made perfectly square, the sand-support could be tilted most easily from its horizontal position into the vertical position if it was oriented so that its side marked "N" was to the north. A similar "N" arrow on the lower side of this sand-support enabled a man below it, after the exit's lid was tied down and before the exit was filled with sand, to position the sand-support for easy tilting and removal when the last of the sand was being cleared from this exit. The sand-support should be cut to fit the exit **after** the exit is completed, because it is difficult to build an exit exactly to specified dimensions.

The top of the emergency exit should be a few inches above the earth around it, to prevent rainwater on the ground from possibly running in. Securely cover the exit's top with a lid of 1/8-inch galvanized steel having a threaded plug-hole (cut from a steel barrel) welded over a hole cut in the lid's center. Such a lid can be closely fitted to the top of a concrete exit by oiling it and pressing it against the concrete before the concrete begins to set.

Before filling the exit with sand, while inside the exit tie the lid down on each of its four sides with nine loops of 3/32-inch nylon cord repeatedly tightened between four galvanized steel "ᒧᒥ's" welded to the lower side of the lid, and four "ᒧᒥ's" set in the shelter's walls and roof slab, as indicated in Fig. 17.2. Use pliers to tighten, stretch, and hold the nylon cord while making the loops. Then after the plywood sand-support is positioned in the bottom of the exit, the exit can be filled by pouring dry sand through the plug-hold in the steel lid. Finally, the plug-hole should be closed so that it cannot be opened, and then made waterproof. To make doubly sure that the lid will not rust, paint it with a cement paint, and then with whatever color outdoor paint you want.

A shelter occupant can cut out the nylon cloth covering the hole in the sand-support, remove all sand and the plywood sand-support from this exit, cut the four tightened nylon-cord multiple loops holding down the lid, push off the lid, and then climb up and step outside — all in less than 5 minutes, even if damp sand has been used to fill the exit. (To make removal of the sand more difficult, in his tests the author used damp sand that does not flow freely and makes it necessary to loosen it repeatedly, with one's hand and arm thrust up through the 8-inch hole in the plywood sand-support.)

In a well designed **blast** shelter this sand-filled emergency exit will provide excellent protection against severe blast. Blast tests have proved that a 1/8-inch steel lid (the equivalent of a blast door) the size of this exit's lid will withstand blast effects of at least 50 psi. Furthermore, sand arching will transfer blast loadings on the sand outward from the slightly downward deflecting plywood sand-support to its edges, and thence to the supporting reinforced concrete rim or ledge around the 23 x 23-inch hole in the shelter's roof slab. (See Fig. 17.2.)

A small shelter with an emergency exit near its far end has additional advantages: It can be supplied with adequate natural ventilation most of the time, with easy forced ventilation by a KAP when forced ventilation is needed, and with daylight illumination. Means for attaining these advantages are described in Appendix F.

ADEQUATE STORAGE SPACE FOR ESSENTIALS

As will be shown in the following sections of this chapter, about 20 square feet of shelter floor area per family member is needed for shelter furnishings and to store adequate water for a month, a year's supply of compact dry foods, cooking and sanitary equipment, blankets, tools, and other post-attack essentials. Twenty square feet per family member also provides enough space per person to store winter clothing and footwear, camping equipment, and foods normally kept on hand and rotated as consumed in the course of ordinary family living. Additional space is needed if you plan to use your shelter as a workshop, or as a fallout shelter to save a few of your unprepared friends without endangering your own family.

SEATS/BUNKS/SHELVES

Seats and overhead bunks built like those specified in Fig. 17.4 and pictured in Fig. 17.5 enable more shelter occupants to sit and sleep more comfortably in less space than when using any other shelter furnishings known to the author. Note that the seat has an adjustable backrest. This backrest is similar to the fine-mesh nylon fishnet backrests tested in a prototype of an expensive blast shelter designed and furnished at Oak Ridge National Laboratory.

Shelter habitability tests have proved the need for backrests. Even some young German soldiers had painfully sore backs after sitting on ordinary benches during a 2-week shelter occupancy test.

Backrests should be installed in peacetime and kept ready for crisis use, rolled up against their upper attachments and covered. Then easily removeable storage shelves, if needed, can be installed between benches and overhead bunks.

To sit or sleep comfortably, pull the bedsheet forward and then sit on about the outer foot of the 2-foot-wide seat.

Although this 5-occupant shelter is illustrated with a bunk for each family member, it is

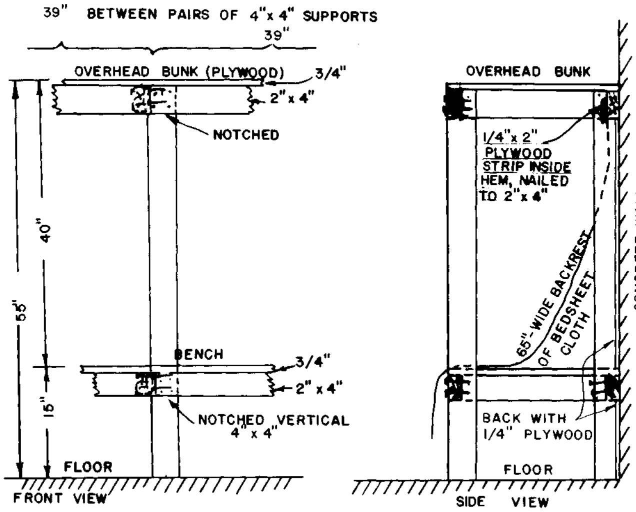


Fig. 17.4. Seat with Overhead Bunk Proportioned for a Shelter Room with a 7-Ft. or Higher Ceiling. A seat with a backrest should be 24 inches wide.

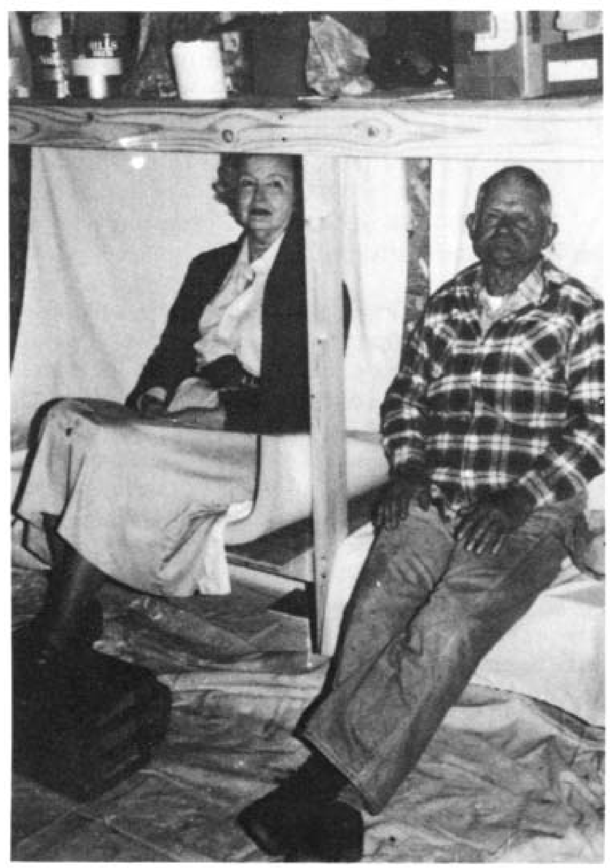


Fig. 17.5. Backrests of Bedsheet Cloth and 2-Inch-Thick Pads Make Sitting and Sleeping Comfortable.

prudent to count on stored supplies making some bunks unusable, and to realize that in a desperate crisis it might be hard to refuse shelter to an unprepared good neighbor. Note that with four persons seated on a 6.5-foot-long seat and one person on the overhead bunk, five persons can be quite comfortably accommodated on 25 square feet of floorspace, including plenty of room for the sitters' legs.

To store the most supplies in a shelter, you should install shelves after you know the heights of the items to be stored. Often the space between an overhead bunk and the ceiling can best be used by making easily removeable additional shelves.

WATER

- **Water needs:** Even most well-maintained shelters do not have enough water for prolonged occupancy. A permanent shelter should provide each occupant with at least 30 gallons of safe water — enough for an austere month, except in very hot weather.

- **Containers:** The most practical water container for shelter storage is a 5-gallon rigid plastic water can with a handle, a large diameter opening for quick filling and emptying, and a small spout for pouring small quantities. A 5-gallon water can of this type sells for about $5 in discount stores.

The plastic bottles that household chlorine bleach is sold in also are good for multi-year storage of drinking water, as are glass jugs. Plastic milk jugs are not satisfactory, because after a few years they often become brittle and crack.

Some shelter owners do not realize that, although a shelter can be kept dry in peacetime, except in the arid West its air is likely to become extremely humid after a few days of crowded occupancy. Very humid air soon softens and weakens cardboard containers of food and flexible water bags.

- **Disinfecting for multi-year storage:** To store safe water and keep it safe for years, first disinfect the container by rinsing it with a strong solution of chlorine bleach. Then rinse it with safe water before filling it with the clear, safe water to be stored. Next, disinfect by adding household bleach that contains 5.25% sodium hypochlorite as its only active ingredient, in the quantities specified in this book's Water chapter for disinfecting muddy or cloudy water. To 5 gallons, add 1 scant teaspoon of bleach. Finally, to prevent possible entry of air containing infective organisms through faulty closures, seal the container's closures with duct tape.

- **Making efficient use of storage space:** A 5-gallon rigid plastic water container typically measures 7 x 12 x 21 inches, including the height of its spout. Nine such 5-gallon containers can be placed on a 2 x 3-foot floor area. Twenty-seven 5-gallon containers, holding 135 gallons of water, can be stored on and over 6 square feet of floor if you make a water storage stand 24 x 42 x 48 inches high, built quite like the seat with overhead bunk described in the Seats/Bunks/Shelves section of this chapter. This easily moveable storage stand should have two plywood shelves, one 24 inches and the other 48 inches from the floor.

- **Using filled containers for shielding:** Filled 5-gallon water containers can be moved quickly to provide additional shielding where needed to increase the protection factor of all or part of a shelter. For example, near the inner door of the shelter illustrated by Figs. 17.1 and 17.2 the protection factor is less than 1000. But if enough filled water containers are placed so as to cover the door with almost the equivalent of an 18-inch-thick "wall" of shielding water, the PF of the part of the shelter room near the door can be raised to about PF 1000.

If a shelter has twenty-seven 5-gallon cans of water stored on and under the above-described 2-shelf water storage stand, then in less than 3 minutes 2 men can shield the shelter door quite adequately. All they have to do is take the 18 cans off the shelves, put 9 of them on the floor against the door and doorway, move the storage stand over the 9 door-shielding cans, and place the remaining 18 cans on the stand's 2 shelves.

Equally good doorway shielding can be provided by placing at least a 24-inch thickness of containers full of dense food, such as whole-grain wheat or sugar, against the doorway. Two 55-gallon drums of wheat, each weighing about 400 pounds, can be quickly "walked" on a concrete floor and positioned so as to shield the lower part of a doorway. Heavy containers on the floor can provide a stable base on which to stack other shielding material.

- **A water well:** The best solution to the water problem quite often is a well inside the shelter. In many areas the water table is less than 50 feet below the surface, and a 50-foot well, cased with 6-inch steel pipe, can be drilled and completed for about $2000. Well drilling should be done after the shelter excavation has been dug and before the concrete shelter floor has been poured. An in-shelter well would be of vital importance not only to the occupants of a family shelter, but later on probably to nearby survivors. Even if only a gallon or so an hour could be bailed from a well too weak to be useful in peacetime, it would be a tremendous family asset post-attack. If infective organisms are found in water from a well drilled to provide water during and after an attack, safe water for months can be assured by merely storing a few gallons of household chlorine bleach.

If enough water for worthwhile peacetime use can be pumped from a well, install a submersible electric pump, with plastic pipe in the well. Then in an emergency the pipe and the attached pump can be pulled by hand out of the well, with only a saw being needed to cut off lengths of the plastic pipe as it is pulled. After the well casing has been cleared of pump, pipe and wires, a homemade 2-foot-long bail-bucket on a nylon rope can be used to draw plenty of water. (See Chapter 8, Water, for instructions.)

● **Local water sources:** Most Americans' normal piped water would not run for months after a large nuclear attack. A month's supply of water stored in your shelter should be adequate, because, even if your area has heavy fallout, in less than a month radioactive decay will make it safe to haul water from nearby sources.

An important part of your shelter preparations is to locate nearby wells, ponds, streams, and streambeds that when dry frequently have water a foot or two below the surface. The author has found that digging a water pit in an apparently dry streambed often supplies enough filtered water to satisfy several families' basic needs. To keep the sides of a water pit dug in unstable ground from caving in, you should drive a circle of side-by-side stakes around the outside of your planned pit before starting to dig. With more work and materials, you and other survivors needing filtered water could dig a well like the Chinese water source shown on page 71. If you are in a fallout area, before drinking water from a water pit you should filter it through clayey soil to remove fallout particles and dissolved radioactive isotopes, as described in the Water chapter. Of course it is prudent to chlorinate or boil all surface and near-surface water after it has been filtered.

FOOD

● **Advantages of a one-year supply:** A family that expends the money and work to build and provision its own shelter should store a year's supply of long-lasting foods. If post-attack conditions enable you to continue living and making a living near your home, having a year's food supply will be a tremendous advantage. And if your area is afflicted with such dangerous, continuing fallout radiation and/or other post-attack conditions that surviving unprepared residents are soon forced to evacuate to better areas, then your and your family's chances will be better if hunger does not force you to move during the chaotic first few months after a nuclear attack.

● **Costs of a one year food supply for a family shelter:** Table 17.1 shows the wide range of 1987 costs of the basic survival foods for multi-year storage that are listed and explained on page 88.

The delivered costs listed in the right hand column include UPS shipping charges in the nearest and least expensive of UPS's 8 zones. For UPS shipping costs to the most distant points in the 48 states, add 34 cents per pound delivered.

All the foods in this survival ration, if stored in moisture-proof and insect-proof containers (the non-fat milk powder should be in nitrogen-packed cans), will provide healthful nutrition for at least 10 years. The exception is the multi-vitamin tablets, which should be replaced every 2 or 3 years, depending on storage temperature. So a family that spends about $300 per member on such a one year survival ration can consider that each of its members has been covered by famine insurance for $30 a year.

Scurvy will be the first incapacitating, then lethal vitamin deficiency to afflict unprepared, uninformed Americans. A multi-vitamin tablet contains enough vitamin C to fully satisfy the daily requirement. However, a prudent shelter owner also should store vitamin C tablets, that keep for years. One hundred 500-mg generic vitamin C tablets — 50,000 mg of vitamin C — in 1987 typically cost about $1.20 in a discount store; a 10 mg daily dose prevents scurvy. After a nuclear war in some areas vitamin C will be worth many times its weight in gold.

● **Sources of the basic foods listed in Table 17.1:**
* **Wheat:** If you live in a wheat producing area, the least expensive sources of ready-to-store wheat usually are local seed-cleaning firms. A hundred pounds or more of hard wheat, dried, bagged, and ready to store in moisture proof containers, costs about 10 cents a pound. (Today the wheat farmer receives about 4.5 cents a pound for truckloads, usually straight out of the field, not dry enough to store except in well ventilated granaries, and containing trash that makes weevil infestations more likely.) In some communities a few stores sell big bags of dry, cleaned hard wheat for 20 to 35 cents a pound.

Shelter owners who are unable or unwilling to obtain wheat from such sources can buy high

Table 17.1. A basic one-year survival ration for one adult male.

Component	Ounces per day	Pounds per year	Range of 1987 retail prices in dollars per pound, FOB, or picked up	Range of 1987 costs in dollars for a one year supply, FOB, or picked up	Range of 1987 costs in dollars for a one year supply delivered and in containers for multi-year storage
Whole-kernel hard wheat	16	365	0.10 to 0.40	36.50 to 135.00	56 to 175
Beans, pinto	5	114	0.25 to 0.79	28.50 to 90.11	38 to 110
Non-fat milk powder	2	46	1.68 to 3.86	77.28 to 177.56	83 to 184
Vegetable oil	1	23	0.36 to 0.57	8.28 to 13.11	9 to 14
Sugar	2	46	0.25 to 0.30	11.50 to 13.80	16 to 20
Salt, iodized	1/3	8	0.17 to 0.20	1.36 to 1.60	2 to 3
Multi-vitamin tablets (low generic, and an expensive brand)	1 per day	365 per year	1.3 to 11.8 cents per tablet	4.75 to 43.07	6 to 44
Total $ costs					$210 to $550

protein hard wheat at higher prices from health food stores and a few mail order companies. The lowest mail order FOB price known to the author for hard western wheat in 1990 is $3.17 for 10 pounds, in a vacuum-packed metallized plastic bag similar to the containers used for some U.S. Army combat rations. This long-lasting wheat, as well as other grains and legumes, is sold by Preparedness Products, 3855 South 500 West, Salt Lake City, Utah 84115. Another reliable mail order source of wheat and other dry foods packaged for multi-year storage is The Survival Center, 5555 Newton Falls Rd., Ravenna, Ohio 44266.

* **Beans,** like wheat, in many communities can be purchased from local farmers' co-ops or local stores at much lower delivered cost than from mail order firms. In one small Colorado town the co-op sold 25 pounds of pinto beans in a polyethylene bag for $11.25—45 cents a pound. Local supermarkets sell bulk pinto beans for around 60 cents a pound.

* **Non-fat milk powder** in 1990 is sold nationwide in the larger cardboard packages for around $2.85 per pound. A better buy for multi-year storage is the instant non-fat milk powder sold by Preparedness Products. This Mormon-owned firm's 1990 FOB price is $57.95 for a case of 6 nitrogen-packed cans, containing a total of 22.5 pounds. The author bought a case three years ago and found this non-fat instant milk powder to be excellent. At $2.58 a pound, plus UPS shipping charges, the cost is considerably less than for comparable milk powder packaged for multi-year storage and sold by other companies.

* **Vegetable oil, sugar, salt,** and **multi-vitamin tablets** are best bought at discount supermarkets. In cities such stores often sell large plastic containers of vegetable oil as "loss leaders" to attract customers, at prices as low as wholesale. Vegetable oil prices in small communities typically are much higher. For an economical survival ration, buy the lowest priced vegetable oil. Remember that one of the worst post-attack nutritional deficiencies will result from chronic shortages of fats (including oils), and that babies and little children cannot survive for a year on a diet of only grains and beans, with no oil or fat. See the Food chapter.

● CAUTIONS: Typical health food stores and most firms that specialize in survival foods sell basic foods at high prices, especially grains, beans, and milk powder. Investigate several other sources before buying.

To make sure that an advertised "one year supply" of survival foods actually will keep an adult well nourished for a whole year, require the seller to inform you **by mail** what his "one year supply" provides a typical adult male in: (1) calories, k cal; (2) protein, g; and (3) fat, g. Then you can use the values in the "Emergency Recommendations" column in Table 9.1 on page 84 to determine whether the advertised "one year supply" is adequate.

● **Transitional foods:** The emotional shock of suddenly being forced by war to occupy your shelter will be even worse if you have to adapt suddenly to an unaccustomed diet. It would be a good idea to occasionally practice eating only your survival rations for a day or two, and to store in your shelter a two week supply of canned and dry foods similar to those your family normally eats. Then it will be easier if war forces you to make the changeover. Of course the transitional foods that you store should be rotated and replaced as needed, depending on their shelf lives.

● **A hand-cranked grain mill:** Whole kernel grains and soybeans must be processed into meal or flour for satisfactory use as principal components of a diet. If unprepared America suffers a nuclear attack, unplanned, local food reserves and/or famine relief shipments will consist mostly of unprocessed wheat, corn, and soybeans. Then a family with a manual grain mill will have a survival advantage and will be a neighborhood asset.

Many health food stores at least have sources of hand-cranked grain mills. Mills with steel grinding plates are more efficient and less expensive than "stone" mills. A mail order firm that still sells hand-cranked grain mills of a make that the author has bought and found to be well made and efficient is Moses Kountry Health Foods, 7115 W. 4th N.W., Albuquerque, New Mexico 87107. It sells a serviceable Polish mill (Model "OB" Hand Grain Mill) for $35.73 FOB, plus UPS shipping charges. This mill cranks easily and grinds wheat into coarse meal or fine flour more efficiently than any of the American manual grain mills that the author has bought and used over the decades. Apparently manual grain mills no longer are manufactured in the U.S. Before buying a grain mill be sure to learn whether it grinds corn, our largest food reserve. In 1987 the author bought an advertised West German mill. Only after receiving it by mail order did he learn by reading the accompanying directions that it is not made for grinding corn.

COOKING AND HEATING

● **Safety precautions:** The first rule for safe cooking and/or heating in a shelter is to do it as near as practical to the exhaust opening. If the fire is under an exhaust pipe, install a hood over the fire. Operate the shelter ventilating pump when cooking, unless a natural airflow out through the exhaust opening can be observed or felt. Keep flammable materials, especially clothing, well away from any open fire.

● **Hazardous fuels:** Charcoal is the most hazardous fuel to burn in confined spaces, because it gives off much carbon monoxide. In a crowded shelter there are obvious dangers in using the efficient little stoves carried by backpackers and in storing their easily vaporized and ignited fuels.

● **"Canned heat":** These convenient fuels are expensive. Sterno, widely used to heat small quantities of food and drink, typically retails in 7-ounce cans for what amounts to about $9.00 per pound.

● **Wood:** The safest fuel to burn in a shelter is wood, the most widely available and cheapest fuel. Furthermore, wood smoke is irritating enough to usually alert shelter occupants to sometimes accompanying carbon monoxide dangers. Scrap lumber cut into short lengths, made into bundles and stored in plastic bags, occupies minimum space and stays dry. Keep a saw and a hatchet in your shelter.

● **Bucket Stove:** The most efficient, practical and safe stove with which to cook or heat for weeks or months in a family shelter is a Bucket Stove, that burns either small pieces of wood or small "sticks" of twisted newspaper. (See the Food chapter.) Especially if you believe that you may have to live in your shelter for months or that your normal fuel will not be available after a nuclear attack, you should make and store at least two Bucket Stoves.

● **An improved Fireless Cooker:** To save a great deal of fuel and time, particularly with slow-cooking grains and beans, make a very well insulated Fireless Cooker similar to the expedient one described on page 82 of the Food chapter. Make a plywood box, first measuring carefully to insure that, when completely lined with 4 inches of styrofoam, the styrofoam will fit closely around a large, lidded pot wrapped in a bath towel. An excellent Fireless Cooker is a war survival asset that also is useful for peacetime cooking.

(To boil about twice as much wheat flour-meal in a given pot as can be boiled when making wheat mush, and to use the minimum amount of water and fuel, salt a batch of the flour-meal, add enough water while working it to make a stiff dough, then make dough balls about 1½ inches in diameter, and roll them in flour-meal. Drop the wheat balls into enough boiling water to cover them, and boil at a rolling boil for 10 minutes. Then put the boiling-hot pot in a well insulated Fireless Cooker for several hours. Corn balls can be made and boiled in this manner, also without the almost constant stirring required when boiling a mush made of home-ground flour-meal.)

● **A sturdy work bench:** In the corner under the emergency exit build a work bench, secured to a wall, on which to cook and to which you can attach your grain mill. A bench 36 inches high, 42 inches wide, and 30 inches deep will serve. (The other corner at the air-exhaust end of the shelter should be the curtained-off toilet and bathing area.)

● **Very warm clothing, footwear, and bedding:** Heating a **well ventilated** shelter usually is unnecessary even in freezing weather if the occupants have these essentials for living in the cold, or if they have the materials needed to make at least as good expedient means for retaining body heat as are described in Chapter 15. The author has felt the warm hands of little Chinese children wearing padded clothing while living in their below freezing homes, where there was scarcely enough straw, grass, and twigs to cook with. If you store plenty of strong thread and large needles in your shelter, you can make warm clothing out of blankets — as some frontier settlers did to survive the sub-zero winters of Montana.

LIGHT

● **White paint:** To make a little light go a long way, paint the walls, ceiling, floor, and furnishings pure white.

● **Candles:** The most dependable and economical lights for a family shelter are long-burning candles. The best candle tested by the author is the 15-hour candle manufactured by the Reed Candle Company of San Antonio, Texas and sold by the millions in New Mexico each Christmas season for use in outdoor decorative "luminarias". This votive-type, short candle is not perfumed and has a wick supported by a small piece of metal attached to its base, so that the wick remains upright and continues to burn if the wax melts and no longer supports it. If burned in one of the candle-lamps described below, this candle gives enough light to read by for 15 hours.

The author has been able to find only one mail order source of 15-hour candles like those sold by the millions in New Mexico: Preparedness Products, 3855 South 500 West, Salt Lake City, Utah 84115. A case of 144 candles sells for $49.00, FOB in 1990. When UPS shipping charges are added, the delivered cost is between 35 and 40 cents for each 15-hour candle, depending on the distance shipped.

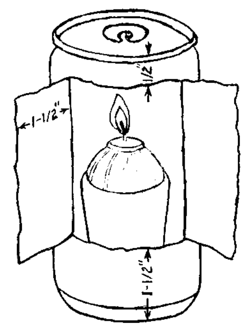
Persons who stock a permanent shelter should realize that after a nuclear war fats, oils, paraffin, and all other sources of light will be in extremely short supply for at least many months. Light at a delivered cost of about two cents per hour will be a bargain blessing.

* The second-best shelter candle tested by the author is a standard Plumber's Candle, that retails for about 60 cents in many stores nationwide, and that burns for about 10 hours with a brighter flame than a votive-type candle.

Two types of expedient candle-lamps were proved by multi-day tests to be the most practical:

* The best expedient candle-lamp is made of a 1-pint Mason jar, identical to the cooking-oil lamp pictured on page 102 of the Light chapter except for the substitution of a short candle for the oil and wick. To make a stable candle base on a glass jar's rounded bottom, cover it with hot candle wax. To be able to light the candle and then put it inside the glass jar, make tongs out of an 18-inch length of coathanger wire bent in the middle, with each of its two ends bent inward 90 degrees and cut off to make 1/4-inch-long candle grippers.

* The second-best candle-lamp is made by cutting a standard aluminum pop or beer can, as illustrated. Use a **sharp** small knife. To make a stable base for a short candle, put enough sand across the can's rounded bottom to barely cover its center. The first candle burned will saturate and then harden the sand, making a permanent candle base or holder.



Caution: Although candles are the safest non-electric lights for shelter use, they produce enough carbon monoxide to cause headaches in a poorly ventilated, long-occupied shelter. In a 2-week habitability test of a family shelter in Princeton, the father and mother did not smoke, yet they had persistent headaches. Specialists later concluded that their headaches were caused by the small amounts of carbon monoxide produced by the candles used both for light and to heat food and drink.

● **Expedient lamps:** The very economical lamp that burns cooking oil in a 1-pint glass jar is the better of the two expedient lamps pictured on page 102. For use in a shelter, however, long-burning candles, that are serviceable after decades of storage, are more practical. Among the disadvantages of expedient lamps is the fact that untreated, soft cotton string needed to make excellent wicks is no longer available in some communities, and making wire-stiffened wicks is a time consuming chore.

- **Other light sources:** See the Light chapter.

NYLON HAMMOCK-CHAIRS

To enable the maximum number of additional people to occupy a shelter for days to months, nylon Hammock-Chairs should be made before a war crisis arises, and should be kept stored for emergency use. The best field-tested model for use in shelters that are at least 7 feet wide is similar to the expedient Hammock-Chair described on pages 120 through 124, is made of strong nylon cloth, and is 40 inches wide by 9 feet long along its center line, with each of its long sides being 8 feet-4 inches long. At each end is a curved hem 3½ inches wide, through which a loop-ended nylon hammock rope is run, to draw the slung hammock into a boat-like, secure shape with adequate head and shoulder room. The breaking strength of a hammock rope should be at least 600 pounds.

To attach the nylon ropes that support the suspended chair's two "arms," a loop of nylon webbing, or of folded and stitched nylon cloth, should be sewn to each side edge of the hammock 52 inches from the end of the hammock that will serve as the top of the back of the chair. See the illustrations on page 124. Especially in permanent family shelters, support points both for the hammocks, and for the hammocks when they are converted into suspended chairs, should be made when the shelter is being built.

OFTEN OVERLOOKED SANITATION AND OTHER SHELTER NEEDS

Store enough soap to last your family for at least a year. After a major nuclear attack the edible fats and oils, used in past generations to make soap, will almost all be eaten. Production of detergents is based on inter-dependent, vulnerable chemical industries not likely to be restored for years.

A chemical toilet would help bridge the gap between modern living and surviving in a crowded shelter. For months-long occupancy, however, a more practical toilet is likely to be a 5-gallon can with a seat, a plastic trash bag for its removable liner, a piece of plastic film for its tie-on cover, and a hose to vent gasses to the outdoors. See page 104. Store at least 200 large plastic trash bags.

The author knows from his experiences in primitive regions that using anything other than paper in place of toilet paper or cloth is hard to get accustomed to. A hundred pounds of newspaper, stored in plastic trash bags to prevent it from getting damp, takes up only about 3 cubic feet of storage space and would be useful for many purposes.

Keep several thousand matches, in Mason jars, so that they will be sure to stay dry even if your shelter becomes very humid post-attack.

Store most of your radiation monitoring instruments in your shelter, along with paper and pencils with which to keep records of radiation exposures, etc. A steel or reinforced concrete shelter should have a transistor radio with extra batteries, and a vertical pipe through which an antenna can be run up to improve reception.

No one can remember all the needed survival facts and instructions given even in this one book, so keep *Nuclear War Survival Skills* and other survival guidance in your shelter, and also other books that you believe may improve your family's morale and survival chances.

PRACTICE SHELTER LIVING

A family that spends a weekend living in its completed small shelter will learn more about unrecognized shelter needs — and more about each other — than members are likely to learn if they all read civil defense information for two whole days. Furthermore, after this educational experience family members old enough to have nuclear fears will know for sure that anti-defense activists are talking nonsense when they maintain that if most Americans had shelters they would become less heedful of nuclear war dangers and more likely to support aggressive leaders.

Appendix E
How to Make and Use a Homemade Plywood Double-Action Piston Pump and Filter

THE NEED

Ventilating pumps—mostly centrifugal blowers capable of operating against quite high resistance to airflow—are used to force outdoor air through most high-protection-factor fallout shelters and through almost all permanent blast shelters. Low-pressure ventilating devices, including ordinary bladed fans and homemade air pumps such as KAPs and Directional Fans, cannot force enough air through a permanent shelter's usual air-supply system consisting of pipes, or of pipes with a blast valve, a filter, and the valves needed to maintain a positive pressure within the shelter.

Manually cranked centrifugal blowers, or blowers that can either be powered by an electric motor or be hand-cranked, are the preferred means of ventilating permanent shelters from Switzerland to China. The main disadvantages of efficient centrifugal blowers are:

1. They are quite expensive. For example, in 1985 a good American hand-cranked blower, that pumps only about 50 cubic feet per minute (50 cfm) through a shelter's pipes, blast valve and filter, retails for around $250. An excellent foreign blower that enables one man to pump somewhat larger volumes sells for about twice as much.
2. Not enough centrifugal blowers could be manufactured quickly enough to equip all shelters likely to be built during a recognized crisis threatening nuclear attack, and lasting for weeks to several months.

Therefore, there is need for an efficient, manually operated, low-cost ventilating pump that:

1. Can pump adequate volumes of outdoor air through shelter-ventilating systems that have quite high resistances—up to several inches water gauge pressure differential.
2. Will be serviceable after at least several weeks of continuous use.
3. Can be built at low cost in home workshops by many Americans, using only materials available in most towns.
4. Could be made by the millions in thousands of shops all over the U.S., for mass production during a recognized prolonged crisis, using only plywood and other widely available materials.

To produce such a shelter ventilating pump, during the past 20 years I have worked intermittently designing and building several types of homemade air pumps. However, until I was traveling in China as an official guest in October 1982 and saw a wooden double-action piston pump being used, I did not conceive or come across a design that I was able to develop into a shelter-ventilating pump that meets all of the requirements outlined above. Now I have made and tested a simple homemade Plywood Double-Action Piston Pump, described below, that satisfies these requirements. Three other persons have used successively improved versions of these instructions to make this model, and several others have contributed improvements.

HOW A PLYWOOD DOUBLE-ACTION PISTON PUMP WORKS

Fig. 1 pictures the box-like test model described in these instructions.

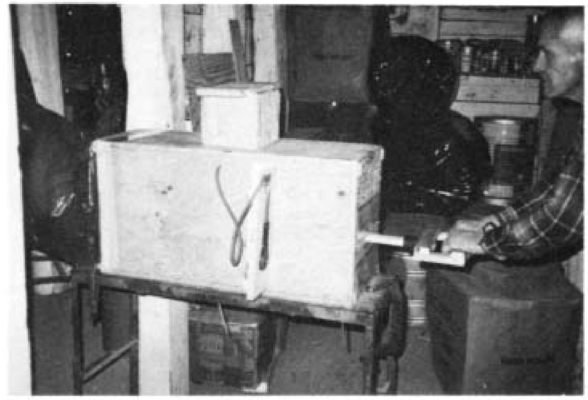


Fig. 1. Plywood Double-Action Piston Pump, with manometer attached for tests.

Fig. 2 illustrates a vertical section through a slightly improved model, and shows the 12x12-in. plywood piston being pushed from right to left, causing air from the outdoors to be "sucked" down the open air-supply duct in the top of the pump, then down to the right through the open valve in the airtight frame (that is above and near the right end of the PARTITION), and on down into the lower-pressure area behind the leftward-moving piston.

Because the air to the right of the leftward-moving piston is at a lower pressure than the air in the shelter room, the exhaust valves in the front end (the handle end) of the pump are held closed.

During this half of the pumping cycle, the higher-pressure air in the part of the pump's square "cylinder" to the left of the leftward-moving piston opens the air-exhaust valves in the back end of the pump, and fresh air is forced out into the shelter room. The higher-pressure air to the left of the valve in the airtight frame (that is above the left end of the PARTITION) keeps this valve closed, while the lower-pressure air to the right of this valve helps keep it closed.

When the piston is pulled to the right, all of the valves shown closed are quickly opened, and all shown open are quickly closed. Then fresh air is forced into the shelter room through the opened exhaust valves in the front end of the pump.

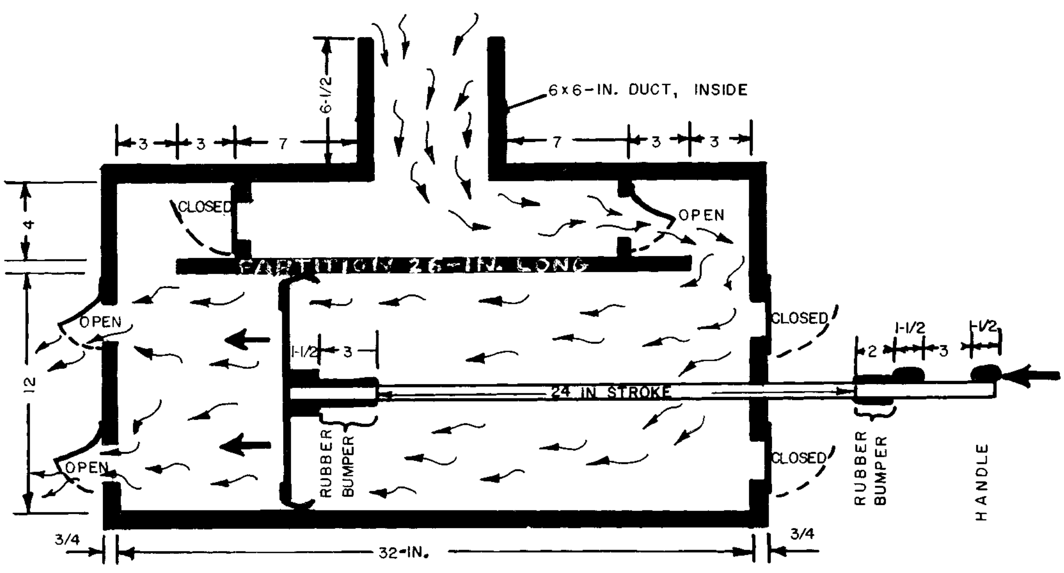


Fig. 2. Vertical Section of the Double-Action Piston Pump showing its square piston being pushed to the left.

PERFORMANCE TESTS

The volumetric and durability tests summarized below are proof that this homemade Plywood Double-Action Piston Pump is better than most hand-cranked centrifugal blowers for supplying a shelter with outdoor air through typical air-intake and exhaust pipes—especially when the ventilation system contains a filter and/or blast valves. The filters that give the best protection, Chemical Biological Radiological (CBR) Filters, have quite high resistance to airflow, as do commercial blast valves that close quickly enough to protect filters.

1. **Volumetric tests.** Because the rapidly pulsating airflows into and out of a piston pump are very hard to measure accurately with an air velocity meter, I made an inflatable cylindrical bag of 2-mil (0.002 inch) polyethylene film; the fully inflated volume of this bag was 256 cubic feet. The bag was suspended on a horizontal strong cord running through its length. A short tube 62 inches in circumference connected the back end of the pump (that is opposite the operator's end) to the suspended bag. Bag and pump were in a below ground shelter that normally has essentially motionless air. See Fig. 1.

Since this type of pump exhausts equal volumes of air from each of its two ends, the total cubic feet per minute (cfm) that it pumps equals twice the cfm that it exhausts into the shelter from one of its ends. See Fig. 1, that shows the pump attached with "C" clamps to a small steel table and being used to pump air into the 256 cubic foot suspended bag.

I measured the pressure differences against which the pump was operated. In a shelter these differences typically are caused by the resistance to airflow in pipes, valves, and a filter. I measured pressure differences in inches water gauge (1 in. w.g. = 0.036 psi) with the small-tube manometer attached to the side of the pump. To produce various pressure differences for several tests, I nailed a piece of plywood over the top of the air-intake duct, so as to produce different sized openings; in most tests I placed different layers of filter materials in a filter box that was fitted airtight over the 6 x 6-in. air-supply duct on the top of the pump. See Fig. 3. (This low-resistance filter removes practically all fallout particles of wartime concern, and also most infective aerosols that may be used in biological warfare. See "Making and Using a Homemade Filter Box and Filter", by Cresson H. Kearny, October 1985.

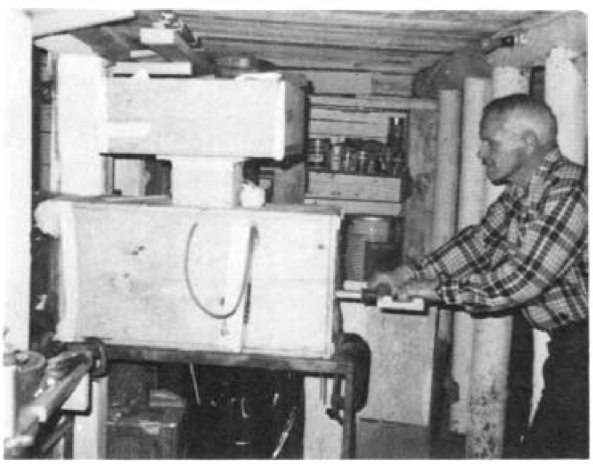


Fig. 3. Pump with Homemade Filter (20 x 20 x 8-inches inside dimensions) connected airtight on top of the pump's 6 x 6-inch air-intake duct.

The best centrifugal blowers that I have seen or heard about are those manufactured by a Finnish company, Temet Oy. (I cranked a Temet Oy blower in an Israeli shelter used for testing ventilation equipment; the Finnish centrifugal blower was better than Swiss, German and captured Russian blowers also undergoing tests.) Therefore, in Table 1 a few of the volumetric tests of my best model Plywood Double-Action Piston Pump (powered by one and two men) are compared with performance data furnished by Temet Oy for its centrifugal blower when cranked by two men. I have converted Temet Oy's metric units into the common American units.

In Table 1 the pressure difference of 4.3 inches water gauge is the resistance to airflow that Temet Oy realistically gives as typical of a well designed shelter ventilation system of pipes, valves and blower plus a Chemical Biological Radiological (CBR) filter. Temet Oy gives 2.0 inches water gauge as typical of the same ventilation system with only a low resistance dust filter. The much larger volume pumped by the Double-Action Piston Pump when a CBR filter is

TYPE OF PUMP	PRES. DIFF. (in. w.g.)	CUBIC FEET PER MINUTE	HORSE-POWER
Double-Action Piston Pump			
one man	4.9	134	?
two men	4.3	182	?
Temet Oy Centrifugal Blower			
two men	4.3	90	0.15
Double-Action Piston Pump			
one man	2.3	172	?
two men	2.3	208	?
Temet Oy Centrifugal Blower			
two men	2.0	300	0.18

Table 1. Comparison of Plywood Double-Action Piston Pump with Temet Oy Centrifugal Blower.

used (as compared to the cfm pumped by this very good centrifugal blower) is typical of the reduced effectiveness of even the best centrifugal blowers at high pressure differences.

In areas devastated by a nuclear explosion, the typical very dusty conditions are likely to result in filters soon becoming dirty and higher in resistance to airflow. Then the greater effectiveness of a piston pump for ventilating a shelter with a high-resistance air-supply system will be even more important than when its filter is clean.

The horsepower requirements of my pump have not yet been measured. However, based on the calculated air pressure on the 12 x 12-in. piston of 22.3 lbs. when the pressure difference was 4.3 in. w.g. (0.155 psi), when two pumpers were making 52 strokes (cycles) per minute while pumping 182 cfm, the horsepower delivered was about 0.14 HP without allowing for friction and the losses of power due to reversals in the directions of piston movements. I estimate that the actual horsepower delivered by the two pumpers (I, a 69 year old with a stiff back in 1983, and a 15-year-old boy) was somewhat less than 0.2 HP. A man in good condition can work for hours delivering 0.1 HP.

When comparing machines powered by human muscles, what muscles are used and how they are used are often as important as are the horsepower requirements. Leg muscles are more efficient and are much stronger than arm muscles. Arm muscles are used much more in cranking a blower than in pushing and pulling the piston of a properly designed reciprocating piston pump back and forth horizontally. See Fig. 3. If this double-action piston pump is placed at a height above the floor so that its handle is approximately at the height of a standing operator's elbows, then the operator can do most of the work with his legs. See Fig. 3. He efficiently moves his body back and forth for over a foot, while moving his hands and forearms horizontally for slightly less than a foot relative to his body. To deliver the same horsepower by cranking a blower uses less efficient muscles inefficiently, and is much more tiring.

As shown in Table 2, the volumetric efficiency of my best model is good for a shelter-ventilating pump. The volumetric efficiency of a piston pump (a positive displacement pump) is found by dividing the cfm actually pumped by the theoretical maximum cfm at the same pumping rate and the same pressure difference, assuming all piston strokes are full length, that all valves open and close instantaneously, and that there is no leakage. Table 2 shows that the greater the pressure difference, the lower the efficiency—as one would expect, because of increased leakage.

PRES. DIFF. (in. w.g.)	STROKES PER MINUTE	cfm	EFFICIENCY
4.0	36	122	84.0%
2.6	45	160	89.0%
0.7	51	188	92.0%
0.4	54	202	94.0%
0.2	55	208	94.5%

Table 2. Volumetric Efficiencies of Double-Action Piston Pump Operated by One Man.

2. **Durability tests.** Finding a homemakeable method to seal the moving piston so as to assure at least one month of continuous efficient pumping was the most difficult problem. Various rubber seals attached to the edges of the piston were unsatisfactory, and aluminum sheetmetal strips (shaped and attached like the galvanized steel sheetmetal strips used in this model) wore out in less than a week, even when oiled every 24 hours.

To save money during weeks of continuous durability testing, the pump was operated by an electric motor that powered a pulley drive that turned a 2-foot-diameter pulley having an attached 40-in.-long steel pitman with a hinged connection to a horizontally-sliding bar connected to the handle of the pump's wooden piston rod. See Fig. 4.

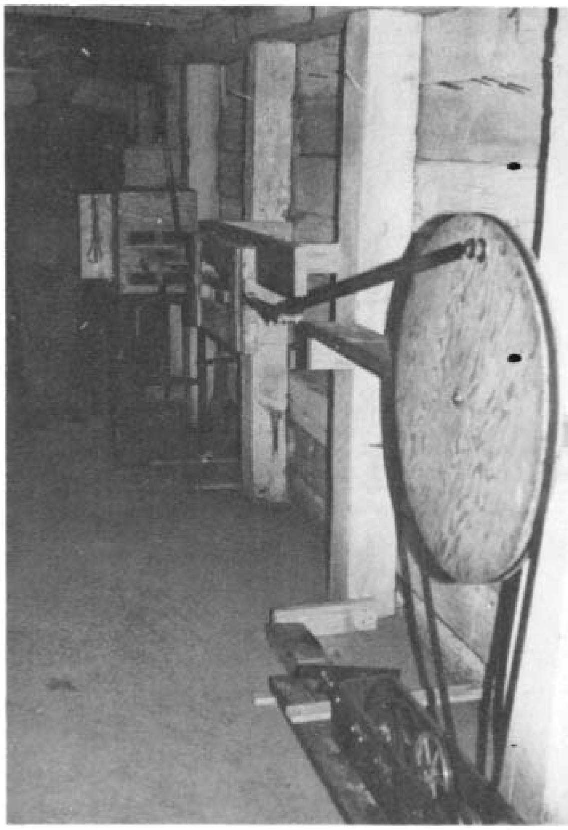


Fig. 4. Mechanized Drive Used in Weeks-Long Durability Tests.

After pumping for 380 hours (15.83 days) at 44 strokes per minute against a pressure difference of 2.3 in. w.g., the worst worn spot on any of the **30-gauge** steel sheetmetal sealing strips on the piston was reduced in thickness from its original 0.0155 in. to 0.0145 in. This worst-spot wear of 0.001 in. is only about a 6% reduction in thickness. The flap valves functioned as well as when new, and appeared unworn.

I conclude that this pump would be serviceable after several months of continuous use—provided it is lubricated after every 24 hours of actual use, as in this durability test. In this test I lubricated the piston, its "cylinder's" four walls, and its rod with Lubriplate No. 105, "the original white grease". This non-sticky "grease-type lubricant" is used extensively, especially to lubricate internal combustion engines before first starting up. Another builder of this model pump found Siloo White Lube, an all-purpose lithium grease, the best of the lubricants that he tested. Judging from my prior durability tests, a very light oil applied daily serves reasonably well. Ordinary bearing grease is unsatisfactory.

MATERIALS

The following materials (that cost about $65. retail in 1985) are needed to make and operate the best model of this pump:

Plywood, 3/4-in. exterior: one 4 x 8-ft. sheet (finished on one side, unwarped).

Plywood, 3/8-in. exterior: 1/4th of a 4 x 8-ft. sheet (finished on one side, unwarped). (Second choice: 1/4-in. exterior plywood).

Oak board, 3/4 x 1-3/4 in., **straight,** well seasoned, 4 ft. long, to make the piston rod. (If oak or other very strong wood is not available, use a **straight** fir or pine board.)

Fir or pine board, about 3/4 x 1-3/4 in., 8 ft. long, to make the piston-rod handle, etc.

28-gauge or lighter galvanized-steel flashing (sold by lumber yards for roofers), no thicker than 0.016 in.; or galvanized steel or flashing no thinner than 0.012 in. Or 30 gauge galvanized steel sheetmetal available in some sheetmetal shops. (Sheetmetal thicker than 0.016 is not springy enough for making this pump's near-equivalent of piston rings.) Best to go to a sheetmetal shop and have 3 strips cut, each 3 in. wide and about 30 in. long.

Screws, round-headed, zinc-plated wood screws:
- 22 each of No. 12 (2-in. long, 12/32 in. dia.), with flat washers
- 10 each of No. 10 (1-1/2 in. long, with flat washers)
- 15 each of No. 6 (3/4 in. long, with flat washers)

Nails, 4-penny (1-1/2 in.), best cement-coated: 1/4 lb.

Nails, 3-penny (1-1/4 in.), galvanized: 1/4 lb.

Staples (if an oak board for the piston rod is not available), No. 17, 3/4-in., galvanized): 1/4 lb.

Tacks, No. 6 upholstery, (1/2-in. long): a small container.

Tacks, No. 3 upholstery (3/8-in. long): a small container.

Felt, weather stripping, 5/8-in. wide: 10 ft.

Tape, silver duct tape, 2-in. wide: a small roll.

Tape, masking tape, 3/4-in. wide: a small roll.

Adhesive, waterproof: "Liquid Nails", or other all purpose construction adhesive: one approx. 11-oz. tube (for use in caulking gun).

Epoxy, 5-minute: 2 tubes.

Rubber cement: a small tube.

Sealer (such as polyurethane clear finish, to reduce absorption of oil or other lubricant of the "cylinder"): 1/2 pint.

Plastic film, transparent storm-window type (such as 4-mil Flex-O-Glass, by Warp Bros.): 3 sq. ft.

Grease-type lubricant, an all-purpose motor-breakin lithium grease such as "Siloo White Lube" or "Lubriplate No. 5 Space Age Lubricant": two approx. 10 oz. tubes.

Inner tube rubber, heavy truck or auto (cut from an old tube): 1 sq. ft.

FUNCTIONAL RELATIONS OF PARTS

Look at Figs. 2, 5, and 6. In Figs. 5 and 6, the lower, fixed part of the front end is pictured below the piston rod. The piston rod slides back and forth on the center of the fixed part of the front end (as indicated more clearly in Fig. 7), and in the notch in the removable part of the front end.

Fig. 5. Front End of the Durability Test Pump, showing the lower fixed part (below piston rod) and the upper removable part, that is held by 6 screws with flat washers. Felt weather-stripping makes the removable part airtight.

Fig. 6. Pump Built by Dale Huber, of Lake City, Florida in his home workshop, while guided only by the second draft of these repeatedly improved instructions. The removable part of the front end has been taken off, to insert the piston into the 12 x 12-in. "cylinder" under the PARTITION. The plastic flaps of this pump's flap valves are black: transparent plastic film is preferred.

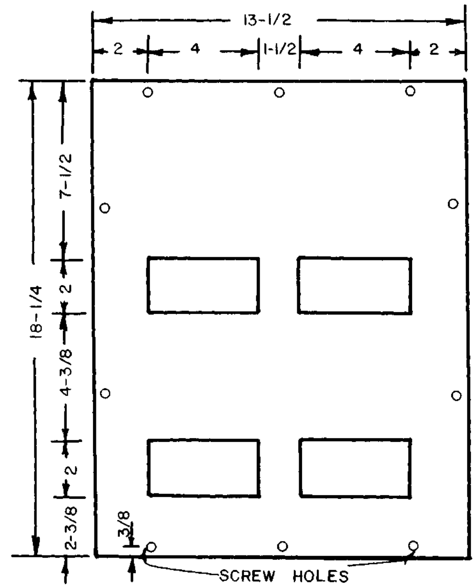


Fig. 8. Back End. Only the plywood is shown.

Note that a single plastic-film flap covers each pair of 2 x 4-in. valve holes, and that, as shown in Fig. 2 (that gives a side view of all six flaps), all flaps open **away** from the vertical center-plane of the pump.

In Fig. 5 the removable (upper) part of the front end is shown in place, secured by six round-head screws with flat washers. In Fig. 7 note the pair of 2 x 4-in. flap-valve holes above the piston rod.

In Fig. 6, the removable part of the front end has been removed, exposing the 26-in.-long, horizontal PARTITION that serves as the top of the 12 x 12-in. "cylinder", in which the piston can make a 24-in.-maximum-length stroke. Also see Figs. 2 and 7. Fig. 6 also shows the piston while it is being removed and one of the two rubber bumpers (made of inner tube rubber) on its piston rod.

The back end of the "box" is made of one piece of plywood, as shown in Fig. 8. The two plastic flaps of its exhaust valves each cover two 2 x 4-in. valve holes, that are positioned the same as the four valve holes in the front end.

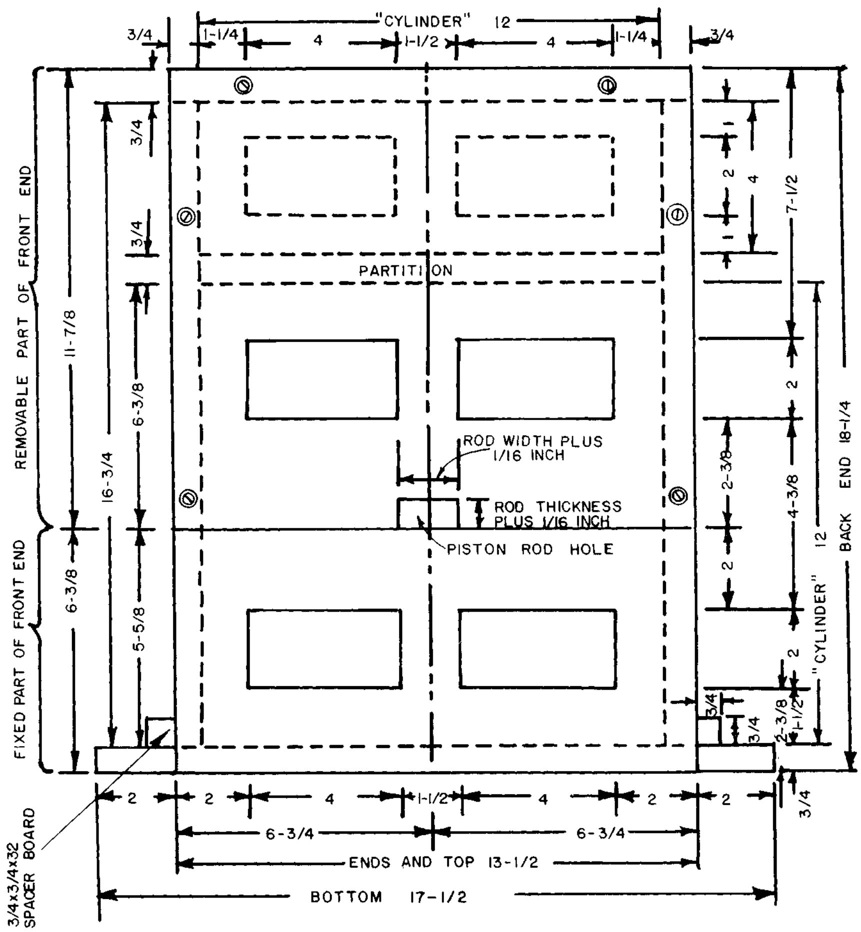


Fig. 7. Front End (Operator's End) of Plywood Double-Action Piston Pump. The two 4 x 12-in. valve frames are shown by dashed lines, as is the 12 x 26-in. PARTITION.

CUTTING OUT THE PLYWOOD PARTS

1. The four parts of the "cylinder" (its bottom, two sides, and the PARTITION; see Fig. 7) should be made with the wood grain of the plywood running in the same direction as the lengths of these parts. This reduces piston friction.

2. Outline on a sheet of **exterior** 3/4-in. plywood all of the plywood parts—except for the 12 x 12-in. piston and the two 12 x 12-in. construction forms, which are made of 3/8-in. **exterior** plywood. (If 3/8-in. plywood is not available, use 1/4-in.) Do not assume that the corners of a sheet of plywood are truly square. Also check the width of the sawcut of the saw to be used, and allow for this width when drawing adjacent outlines of parts on the plywood. Be sure to make all corners **square**.

3. If you do not have a table saw that saws accurately, or a heavy-duty saber saw, you will do well to pay a professional carpenter or cabinet maker to saw out the plywood parts—and also the piston rod if you are making it out of an oak board. A professional can accurately saw out all of the plywood parts and the 10 valve holes in about 2 hours, provided you have accurately outlined all saw lines.

4. Make the following plywood rectangles with tolerances of + or - 1/32 in.:

PARTITION, 12 x 26-in.
Two sides, each 16-3/4 x 32-in. (If your "3/4-in. plywood" actually is less than 11/16-in. thick, make the height of each of your sides 16-3/4-in. less the difference between 3/4-in. and the actual thickness of your plywood. See Fig. 7.)
Bottom, 17-1/2 x 32-in.
Top, 13-1/2 x 32-in.
Two valve frames, each 4 x 12-in.
Piston, 12 x 12-in. (of 3/8-in. plywood).
Two construction forms, each 12 x 12-in. (of 3/8-in. plywood).

5. Make the following plywood rectangles with tolerances of + or - 1/16 in.:

Back end, 13-1/2 x 17-1/4-in. (See Fig. 8.)
Removable (upper) part of front end, 13-1/2 x 10-7/8 in. (See Figs. 7 and 9.)
Fixed (lower) part of front end, 13-1/2 x 6-3/8-in. (See Figs. 7 and 10.)
The four parts of the air-intake duct: two each 6-1/2 x 6-in.; two each 6-1/2 x 7-1/2-in.
Two spacers (to be nailed to the bottom) each 3/4 x 3/4 x 32-in.

6. Saw out the 10 valve holes; a tolerance of + or - 1/8 in. is good enough. (See Figs. 7, 8, 9, and 10.)

7. Saw a square 6 x 6-in. hole in the center of the top, as shown in Fig. 2 — if you are going to install the homemade filter (described in separate instructions) directly on top of your pump. (To connect your pump to a round air-intake pipe, cut an appropriate round hole in the top.)

8. Sandpaper the finished sides of the PARTITION, the two sides, and the bottom, to reduce friction on the reciprocating piston. Use fine sandpaper.

9. Make and attach the 6 valve flaps, to complete the flap valves, that are the lowest resistance, quickest acting type tested.

a. Make a 3-3/4 x 5-3/4-in. cardboard TEMPLATE, using carbon paper to transfer lines of Fig. 11 to cardboard. (See Fig. 11 on page 7, and note that this TEMPLATE outlines the **right** half of the 3-3/4 x 11-1/2-in. plastic-film flap.) Also transfer the dashed tack-line and mark the ends of the 4 horizontal stop-string lines. Drill 8 small holes through the cardboard at the ends of the 4 stop-string lines, so that you can use a pencil to mark these points on plywood.

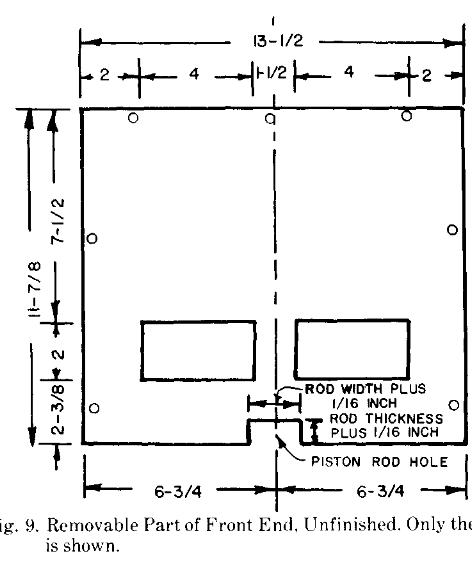


Fig. 9. Removable Part of Front End, Unfinished. Only the plywood is shown.

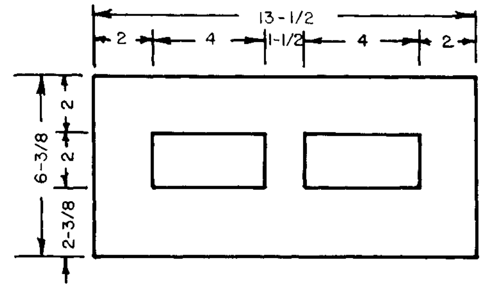


Fig. 10. Fixed Part of Front End, Unfinished. Only the plywood is shown.

b. Use your TEMPLATE to mark around the 2 x 4-in. valve holes in plywood parts: (1) the positions of the ends of each hole's 8 stop-strings, (2) the **right** side-edge and the bottom-edge of each flap after it is attached, and (3) the tack-lines.

c. Drill a 1/16-in. diameter hole through the plywood at each point marked for an end of a stop-string.

d. With nylon kite string (or other nylon string about 1/16-in. in diameter, such as 50-lb-test nylon fishing line) and a big enough needle, string the "four" stop-strings across each 2 x 4-in. hole. (Use a string long enough to make "four" uncut stop-strings.) Start on the unfinished, back side of the plywood, on the opposite side from the future valve flap. To secure the starting end, wrap the string around a half-driven tack, and then drive it in. Keep pulling the string **tight** as you thread it through the holes and as you wrap its finishing end around a half-driven tack. Finally epoxy the string in all of the holes, on the back side of the plywood. (An equally strong nylon string can be made by twisting together 4 pieces of waxed nylon dental floss.)

(Stop-strings also can be positioned by using No. 3 upholstery tacks in place of the 1/16-in. diameter holes. Drive a tack partly in, wind the string around it while pulling the string tight, and drive the tack completely in, to hold the string securely. Finally, coat the tack heads and the adjacent plywood with a smooth covering of adhesive, to provide a smooth seat for the valve flap.)

e. Cut out 6 plastic flaps of transparent 4-mil plastic film (each 3-3/4 x 11-1/2 in.). The easiest way to accurately cut a flap of thin plastic film is to make a cardboard template 3-3/4 x 11-1/2-in., place it on the film, and cut around it with a very sharp knife.

f. In preparation for attaching a flap over each pair of 2 x 4-in. valve holes, cover the plywood **above** each pair of holes with masking tape, up to the straight "tack line" that you already have drawn 1/2 in. **above** each hole. Use your cardboard TEMPLATE. The masking tape will prevent the adhesive (that will be used to attach each valve flap) from being applied too near the 2 x 4-in. holes, where adhesive would keep a flap from opening fully.

g. Position each of the 6 flaps properly in its closed position, with its lower edge on the line that you already have used the TEMPLATE to draw 3/4 in. below each flap's pair of 2 x 4-in. holes. Position its **right** side-edge on the line already drawn 1 in. from the right side of the right hole of each pair of 2 x 4-in. holes. Then put masking tape over the lower edge of each flap and the adjacent plywood, to hold the flap temporarily in its closed position.

h. Gently fold down the upper part of each flap, so that the plywood above its pair of 2 x 4-in. holes is uncovered (except where you have placed the protective tape), and place small pieces of masking tape so as to hold each flap temporarily in this folded-down position.

i. Quickly apply a thin coat of all-purpose construction adhesive (such as Liquid Nails) to a 1/2-in.-wide plywood area above the protective masking tape that covers the plywood up to the "tack line" 1/2 in. above each pair of 2 x 4-in. valve holes. Then promptly detach the small pieces of masking tape holding the flap in its folded-down position, and turn the flap (the lower part of which is still being held in its proper closed position by masking tape) into the whole flap's closed position. Press the upper part firmly against the approximately 1/2-in.-wide coating of adhesive, to secure the valve in its proper closed position. Allow several hours for the adhesive to harden before removing the tape and using the valve.

j. Drive small tacks (No. 3; 3/8 in.) on the "tack line" (see TEMPLATE), to make sure the flap stays securely attached after long use. (Very small tacks are easily driven if held with tweezers or needle-nosed pliers.)

PUTTING THE PUMP "BOX" TOGETHER

1. The following procedure is the best tested construction method for persons who lack experience in putting parts together so that all corners are exactly square, or who do not have the big clamps and other glueing equipment used by cabinet makers. This procedure is best carried out by two persons working together.

2. On the finished side of the top, draw two parallel lines exactly 12 in. apart and parallel to the top's 32-in.-long edges. Each of these lines will be 3/4-in. from an edge. Also draw a line 6 in. from and parallel to each end of the top, to mark the positions of the two valve frames. See Fig. 2.

3. Build the pump's "box" **upside down**; start by placing its top on the floor, as indicated by Fig. 12.

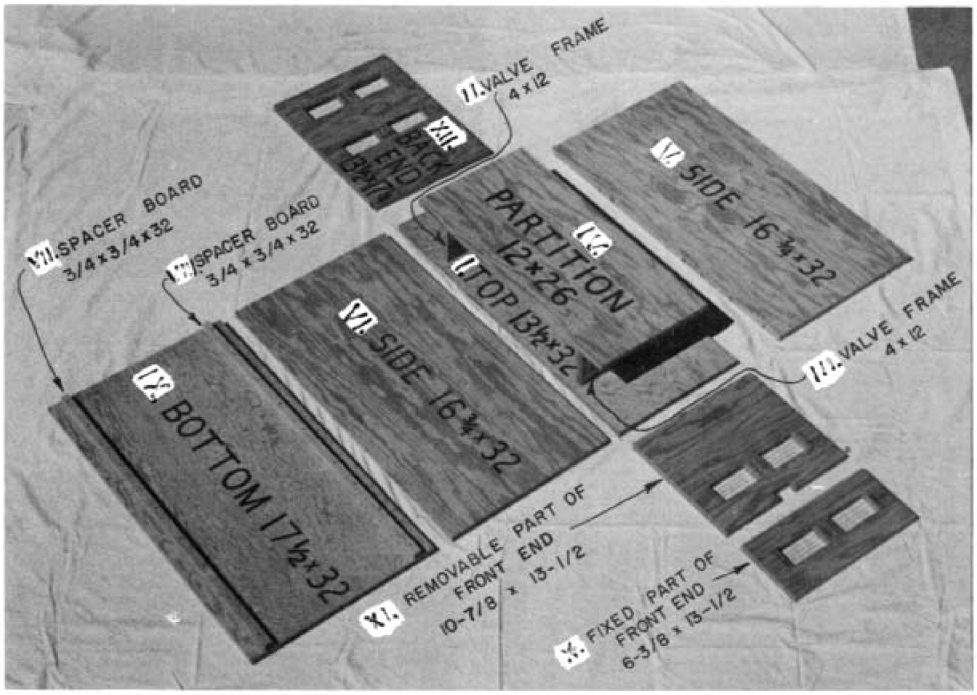


Fig. 12. Parts of the Pump "Box", with Dimensions in Inches. The Roman numbers give the best tested order for attaching these parts to each other.

4. Attach the two valve frames II and III to the top I with construction adhesive, positioning each of them 6 in. from an end of the top I. Make sure that each frame's flap valve is **upside down** and **facing away from the center** of the pump. Remove any adhesive that is on the top beyond the ends of the valve frames.

(When using construction adhesive to make this pump, it is best to apply a rather thin coat to only one of the two plywood surfaces to be joined. Then promptly rub one plywood part slightly back and forth against the other, while pressing them together—thus making sure that both surfaces are coated and in close contact. Wait until the adhesive sets and bonds adequately before attaching more parts.)

5. Draw two parallel lines on the unfinished side of the PARTITION, each 3 inches from one of its ends. Adhere the two 12-in.-long unattached edges of the valve frames to the PARTITION on these two lines, as illustrated by Figs. 2, 7 and 12. Allow time for the adhesive to set.

6. Before permanently attaching side V, position it vertically with a long edge resting on the top, and with a side-edge of the PARTITION and ends of the two valve frames I and II in contact with the finished side of side V. See Fig. 7. On the unfinished (outer) side of side V draw lines showing the positions of the PARTITION and of the two valve frames in contact with the finished side of side V.

7. Preparatory to attaching side V to the PARTITION and to the two valve frames, drill 4 slightly oversize screw holes (for your 2-in. roundhead screws) through side V. Drill these holes so that a screw will go into an end of each valve frame about 1 in. from its adhered edge, and the other 2 screws will go into the side-edge of the PARTITION, at points above the valve frames. Next, with side V temporarily in its final position, drill with a smaller diameter drill through the 4 holes in side V, into the PARTITION and into the two valve frames. Then with the 4 screws temporarily connect side V, the PARTITION, and the two valve frames, and, while checking with a carpenter's square the squareness of the angle between the PARTITION and side V, adjust the two pairs of screws to attain squareness. Remove side V.

8. Apply adhesive to the 3/4-in.-wide area along the long edge of the top, and if necessary a thicker coating of adhesive than normal to unattached edges of the PARTITION and of the two valve frames. Then promptly position side V, and by again screwing in and adjusting the 4 screws, make the angle between the PARTITION and side V **square**. Allow the adhesive to set.

9. Use short pieces of duct tape to temporarily attach the two 12 x 12-in. construction forms to the PARTITION and to side V. (Before using these forms, drive 4 small nails into each form, near its corners, to serve as handles for removing them from the completed "cylinder".) Attach a construction form near each end of the PARTITION.

10. Adhere the finished side of side VI to the top, to the unattached side-edge of the PARTITION, and to end-edges of the valve frames, while keeping side VI pressed against the two **square** construction forms. To keep side VI pressed against the construction forms until the adhesive sets, use small nails to temporarily nail two small boards horizontally across the ends of the sides, at each end of the "box".

11. On the finished side of the bottom IX, draw two parallel lines 13-1/2-in. apart, making each line 6-3/4-in. from the center line of the bottom, as shown in Fig. 7. Nail the two 3/4 x 3/4 x 32-in. spacer boards VII and VIII to the bottom, 13-1/2-in. apart.

12. To attach the bottom, first place it (with its finished side **down**) on the exposed long-edges of the sides. If you find that the bottom rests on the construction forms and is not in contact with the long-edges of the sides, in effect increase the heights of the sides by coating with adhesive both the edges of the sides and the 3/4-in.-wide area of the bottom to which the sides will be adhered. Then adhere the bottom onto the edges of the sides. Before the adhesive hardens, remove any that has been squeezed into the corner of the "cylinder".

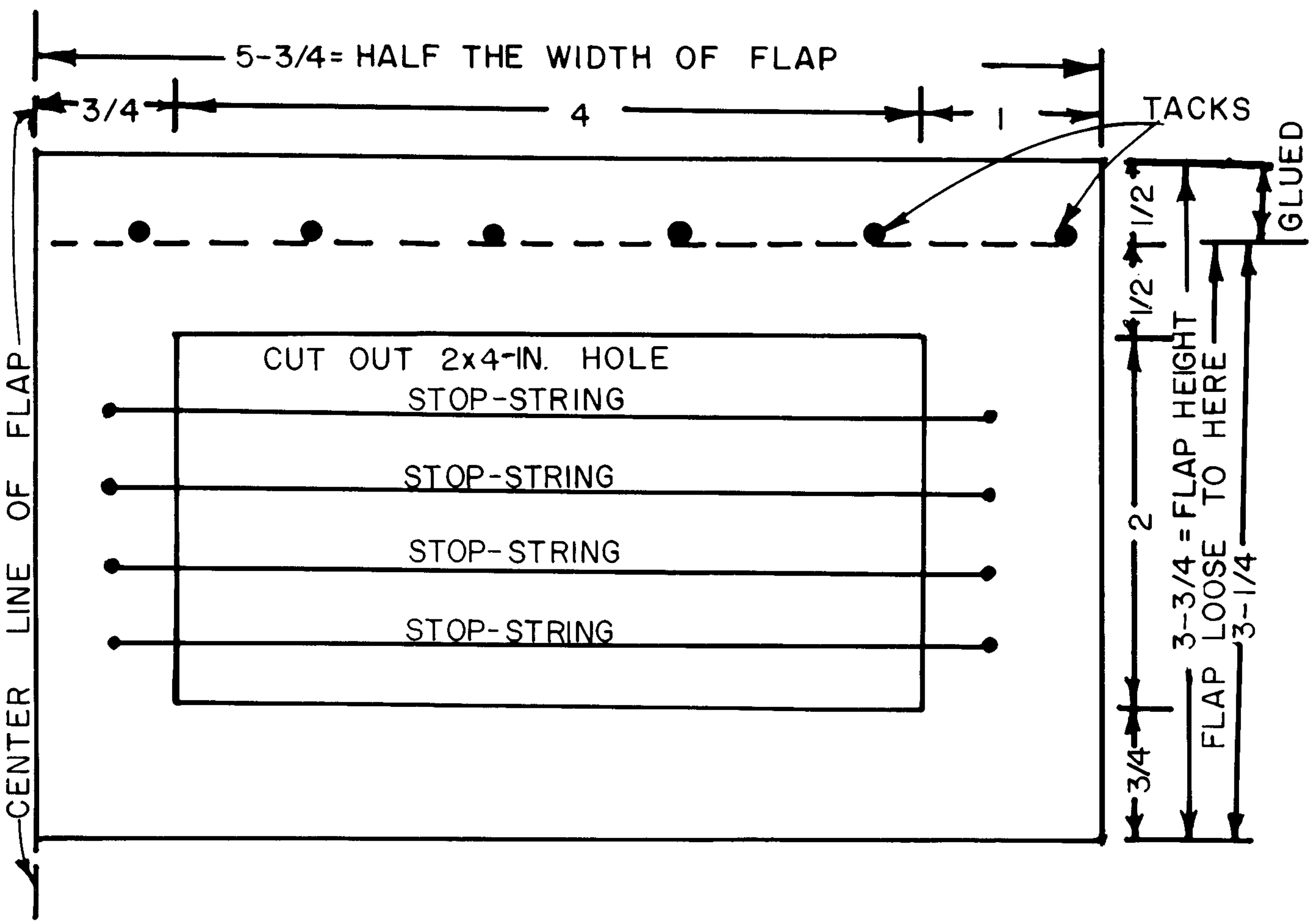


Fig. 11. TEMPLATE for Positioning the Stop-Strings of each of the 12 valve holes, and for attaching each of the 6 valve flaps.

TRACE THIS DRAWING. TO MAKE THE WORKING TEMPLATE, TRANSFER THE TRACING TO A PIECE OF CARDBOARD. CUT OUT THE 2 X 4-INCH HOLE IN THE CARDBOARD, AND MAKE SMALL HOLES SHOWING THE POSITIONS OF THE STOP-STRINGS AND TACKS.

13. Permanently attach the fixed part of the front end X (see Fig. 7, 10 and 12) with adhesive and small nails to the sides and to the bottom. Be sure that its flap valve is **upside down** and is **facing away from the center** of the pump, and that a long edge of this part is level with the outer side of the bottom. Remove the construction forms.

14. Paint the interior of the "cylinder" with sealer—after removing all adhesive that may be in its corners.

15. After the sealer dries, sandpaper the interior of the "cylinder" with fine sandpaper, and paint it again with the final coat of sealer.

16. To attach the removable part of the front end XI, stand the "box" on its completely open end and drill slightly oversize screw holes (for your 2-in. screws) clear through the removable part of the front end, as indicated by Fig. 9. With the flap valve **facing outward**, temporarily attach this part with a few small nails to the end of the top and to ends of the two sides. Then with a smaller-diameter bit, drill the screw holes deep enough into the top and the sides so that the 7 screws will hold securely.

17. So that it will be unnecessary to tightly screw on the removable part of the front end in order to make its repeated temporary attachments airtight, tack felt weatherstripping (best 1/8-in. thick and 5/8-in. wide), or strips made of two thicknesses of flannel, to the contact edges of the top and the sides. No. 3 (3/8-in.) carpet tacks serve well. Then with a razor blade carefully cut the felt covering the screw holes in the edges, and remove these small pieces of covering felt.

18. Attach with screws the removable part of the front end.

19. To prevent damage to the front-end valve flaps when you stand the pump on its front end, epoxy a small piece of 3/8-in. plywood to the front end, near each of its four corners, as pictured in Figs. 3 and 5. Before standing the pump on its front end, use small pieces of masking tape to temporarily secure its valve flaps in their closed positions.

20. Attach the back end XII, using only screws. See Fig. 8. (For repairs, the back end may have to be removed.) To make the attachment of the back end airtight, coat its attachment "crack" only with rubber cement.

MAKING THE PISTON, THE PISTON ROD, AND ITS HANDLE

1. Have a sheetmetal shop cut three 3-ft.-long, 3-in.-wide strips of galvanized steel sheetmetal that is **no more than 0.016-in. thick** and no less than 0.012-in. thick. (Most galvanized steel valley flashing used by roofers and sold by many lumber yards is less than 0.016-in. thick; 30-gauge galvanized sheet metal sold by some sheetmetal shops is about 0.015-in. thick.) Steel sheetmetal thicker than about 0.016 in. is not springy enough and is unsatisfactory.

2. With a tolerance of + or - 1/32-in., cut from these strips two strips each 11-13/16-in. long, and two strips each 11-3/4-in. long. (These four strips first must be bent and then tacked to the four sides of the plywood piston; these piston-sealing strips serve rather like piston rings, by making close, sliding, low-friction contact with the sides of the plywood "cylinder". Steel strips resist wear and if properly lubricated make the pump serviceable for months of continuous use.)

3. Preparing the four sheetmetal sealing strips:

a. Since the strips to be tacked to the top and the bottom of the piston must be bent differently from the strips to be tacked to its two sides, mark "T or B" on each of the two strips that are 11-13/16 in. long, and mark "S" on each of the two strips that are 11-3/4 in. long.

b. On each of the two strips marked "T or B", draw an ink line along which to make the approximately 30 degree bend, and another line for the approximately 90 degree bend. (See the left half of Fig. 13 for the distances from the edges of these two "T or B" strips to their bends.) Also draw two ink lines along which to drive tacks, spaced as shown in the left half of Fig. 13.

Likewise draw four lines on each of the two strips marked "S", as specified in the right half of Fig. 13, noting that some of these lines are spaced differently than corresponding lines on the strips marked "T or B".

c. Using a small sharpened nail for a punch and placing one strip of sheetmetal at a time on a smooth board, punch 2 rows of tack holes in each strip. The tack holes should be about 1-1/2 in. apart.

d. From a nominal 1 x 2-in. **straight** board, make two boards each about 3/4 x 7/8 x 12-1/4 in., for use in bending the sealing strips.

e. Securely sandwich a "T or B" strip of sheetmetal between the two 12-1/4-in.-long boards placed exactly on top of each other, by tightening two "C" clamps on the ends of the two boards, so that the bending line 3/8-in. from one side of the strip is just visible along the straight edge of a board. Then hold the two clamped boards in a vise so that the 3/8-in.-wide part of the sheetmetal strip is uppermost and vertical.

f. Bend the exposed part of the strip about 30 degrees off the vertical, **away** from the side of the strip where the holes have been indented by the punch. To bend evenly, hammer gently and repeatedly on a 3/4 x 3/4 x 18-in. board held against the exposed 3/8-in.-wide part of the strip.

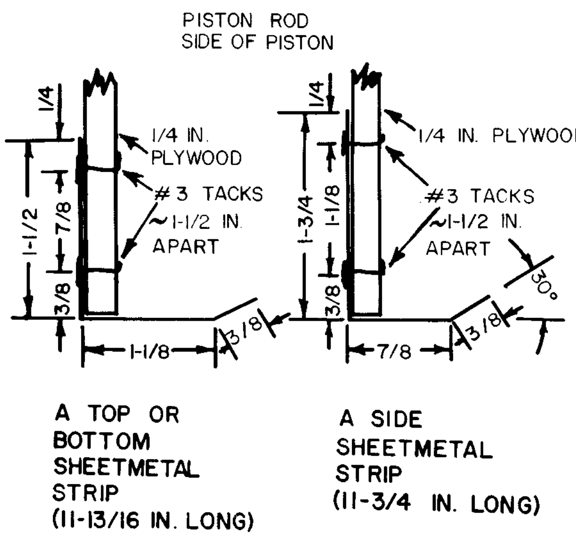


Fig. 13. Piston Sealing Strips, each made of a springy sheetmetal strip 3 in. wide.

g. With the sheetmetal strip held sandwiched between the two 12-1/4-in.-long boards by the two "C" clamps and the vise, so that the bending line for the almost 90-degree bend is barely visible, bend the exposed part of the strip 90 degrees, in the same direction that the 3/8-in.-wide part was bent. See Figs. 13 and 14.

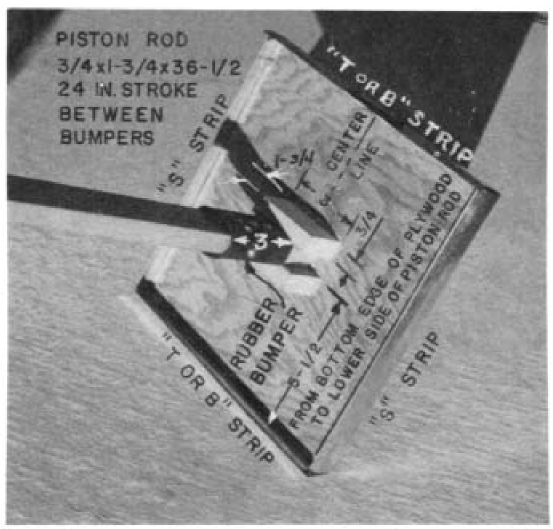


Fig. 14. Plywood Piston with Sheetmetal Sealing Strips Attached.

h. Bend the other "T or B" strip, and similarly bend each of the two "S" strips.

4. Attach the four sheetmetal sealing strips to the plywood piston with No. 6 tacks (1/2-in. long). Place on a solid metal surface the part of the plywood piston opposite the spot to which part of a strip is being tacked, so that when a tack is hammered in its point is **clinched** (bent over) on the far side of the 3/8-in.-thick plywood piston, by being hammered against the solid metal surface.

a. First tack a "T or B" sheetmetal strip to the top of the piston, and a "T or B" strip to its bottom.

b. Then tack the two "S" strips to its sides. The strips should fit together so as to make square corners. If adjacent ends of two strips do not fit neatly together, cut bit by bit a very little off the end(s) of a strip(s) so that the two adjacent ends fit together neatly at their corner.

c. To prevent air leakage between the ends of the sealing strips, put rubber cement in the four corner "cracks" between strips. (This was not done on the test pump's piston.)

5. For the piston rod, saw from a **straight, well-seasoned** oak board a 3/4 x 1-3/4 x 36-1/2-in. board. Sandpaper it smooth. (A piston rod made of well-seasoned oak is less likely to break if abused, but necessitates using screws, in place of nails and staples, for attachments. Piston rods made of nominal 1 x 2-in. fir boards were undamaged in the tests.)

6. To complete the piston rod:

a. For the handle, use 4 pieces of a nominal 1 x 2-in. board cut to the lengths shown in Fig. 15. Also see Fig. 16. Round all edges and corners, to minimize the chances of the operators' blistering their hands.

b. Paint the piston rod and its handle with sealer. When dry, sandpaper. Then apply a final coat of sealer.

c. Use adhesive, screws, and nails (or adhesive and nails if your piston rod is of soft wood) in making the handle illustrated by Fig. 15.

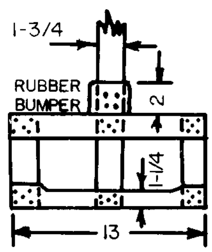


Fig. 15. Piston Rod Handle Made of 3/4 x 1-3/4-in. Boards.

Fig. 16. The Pump Handle of the Durability-Test Pump, showing how one man best holds it when two men are pumping.

d. To reduce friction on the piston rod and resultant enlargement of the piston-rod hole with long use, coat with epoxy all four sides of the piston-rod hole. See Figs. 7 and 16. Be sure that the piston rod slides snugly yet freely in its hole when the removable part of the front end is screwed in place.

e. From a piece of thick truck-tire inner-tube rubber, cut a 2-in.-wide strip 12-in. long. To make the 2-in.-wide rubber bumper (see Figs. 15 and 16), connect one end of this rubber strip to the center of a 3/4-in.-wide side of the piston rod. Do not place any screw or staple in the strip closer than 1 in. from the strip's forward edge, that may repeatedly bump into the front end. Wrap and attach the strip quite tightly around the piston rod next to the handle. (If you have only a piece of passenger-car inner-tube rubber, then to make a 2-in.-wide bumper use a 4-in.-wide strip of this thinner rubber folded double lengthwise.)

7. Attaching the piston rod to the piston:

a. On the back of the 12 x 12-in. plywood piston, mark lines to enable you to attach the piston rod as pictured in Fig. 14. Note that the **lower side** of the piston rod is exactly 5-1/2 in. above the lower edge of the plywood of the piston, and that the center line of the piston rod intersects the vertical center line of the plywood of the piston.

b. To the end of the piston rod (see Fig. 14) adhere and screw (or adhere and nail if your piston rod is not oak) two pieces of nominal 1 x 2-in. boards each 3 in. long. Each of these two small boards and the end of the piston rod are in contact with and securely connected to the plywood piston, and form a perfect "T" at the end of the piston rod.

c. Connect the piston rod to the piston, best with epoxy (or adhesive) and small screws. Make sure that: (1) the four piston sealing strips overlap the piston's plywood in the direction of the piston rod, (2) the 1-3/4-in.-wide sides of the piston rod are parallel to the top and bottom of the piston, and (3) the piston rod is perpendicular to the piston. See Figs. 2 and 14.

d. Make and attach to the piston rod a 3-in.-long rubber bumper, positioned close to the piston as shown in Fig. 2.

OPERATING THE PUMP

1. Check to see that the four sheetmetal strips on the four sides of the piston all make even contact with the walls of the "cylinder" when the piston is moved back and forth. If the piston does not slide back and forth quite easily even when not lubricated, carefully bend a strip or strips so that they press less against the "cylinder" walls. If while someone is shining a flashlight through a valve opening in the other end of the pump you observe that parts of a sheetmetal strip do not make close contact with a "cylinder" wall, gently bend outward that part of the strip.

2. Lubricate all four walls of the "cylinder", the sheetmetal strips that slide against the walls, and the piston rod. Use a very thin motor-breakin white lithium grease (not an ordinary bearing grease, that is too sticky). Or use a thin oil. The pump should be lubricated after no more than each 24 hours of use, and before being used again after days of disuse.

3. Install the pump at a height above the floor so that most of the persons who are going to pump can push and pull with their hands moving at about the same height that their elbows are when they are standing. See Fig. 3 for an example of a pump-supporting table raised to an efficient height for operators who are the height of the pumper pictured.

4. To save work and to minimize wear on the pump, usually operate it with a length of stroke a little shorter than the distance between its two rubber bumpers. To save energy especially when pumping air through a high resistance ventilation system, move the piston back and forth by using mostly your leg and body muscles.

PROLONGED STORAGE

Wipe off all grease and other lubricants if you do not plan to use this pump for months. All lubricants—especially those on wood—tend to become gummy with time.

Keep your supply of pump lubricants taped to your pump.

REQUEST

Suggestions for improving this pump and/or these instructions will be appreciated, and may contribute to improvements likely to save lives.

Cresson H. Kearny

FILTER BOX AND FILTER

PURPOSES

The primary shelter ventilation requirement is to supply enough outdoor air to maintain endurable heat-humidity conditions.

To keep the concentration of respiratory carbon dioxide low enough for survival, very little fresh outdoor air is required. Even for an infant or an infirm person remaining in a crowded shelter for days, 3 cubic feet per minute (3 cfm) is adequate. For a healthy adult or child 1.5 cfm is enough. Too much carbon dioxide, not too little oxygen, is the initial cause of unendurable conditions in inadequately ventilated shelters in which the air does not get unendurably hot.

In contrast, up to 25 cfm of outdoor air per occupant may be needed to maintain endurable heat-humidity conditions inside a crowded shelter occupied for days during a heat wave in a hot, humid part of the U.S. Hence the need for a large-volume ventilating pump, best with a low-resistance filter.

If outdoor air flows into a shelter through a hood, gooseneck pipe, or other air-supply opening that causes all but tiny fallout particles to fall out before the air reaches shelter occupants, breathing this unfiltered air will not result in short-term radiation casualties. However, a very small fraction of the occupants of a shelter supplied with unfiltered air in an area of heavy fallout may contract cancer years later as a result of breathing shelter air containing tiny fallout particles, that a properly designed filter could have removed.

Air that has been in contact with fallout particles before being filtered is not radioactive.

The homemade filter illustrated below, if used with an efficient "suction" pump such as the Plywood Double-Action Piston Pump described separately, will remove practically all fallout particles likely to cause casualties even decades later. This filter also will remove most infective aerosols, the air-borne tiny particles used in biological warfare — an unlikely type of attack on the United States. It will not remove poisonous gasses, an even less likely danger to Americans if all-out war befalls us.

CONSTRUCTION

Filter Box

If 20 x 20-inch furnace filters are available, use plywood or boards to build the filter box shown in the illustration. To make permanent connections airtight, first use waterproof construction adhesive or glue, and then tape. (If only smaller filters are available, reduce the horizontal dimensions of the box accordingly, except for the top and bottom openings.) Check to be sure that your filters will fit snugly in the box of the size you plan to build.

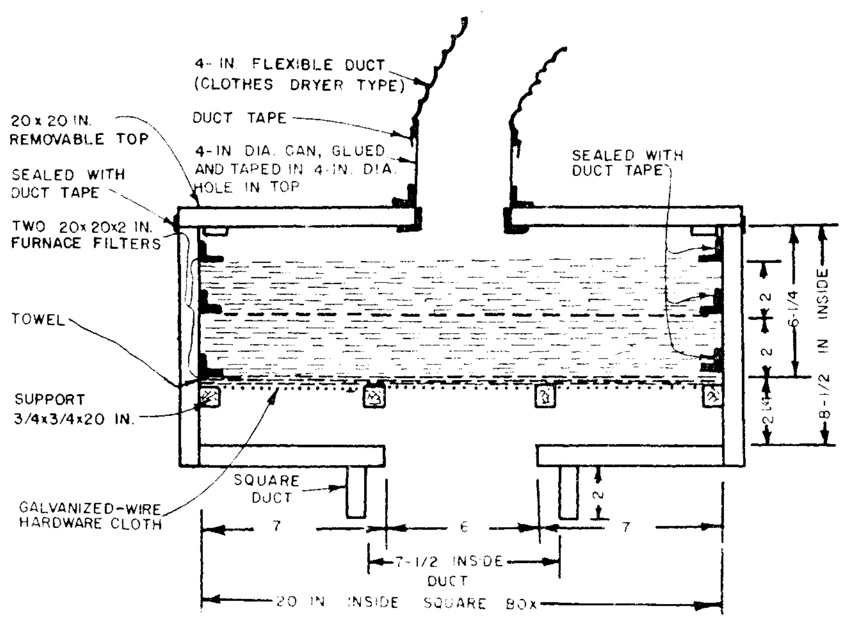
The square frame on the bottom of the filter box should fit snugly over the square air-intake duct on the top of your Plywood Double-Action Piston Pump. Tape the cracks to make the connection airtight and to permit easy removal of the filter box.

Make the illustrated 4 supports of the hardware cloth no thicker than 3/4 inch, thus providing enough space below the filter for low-resistance airflow. (Hardware cloth is a stiff, square-mesh, molten-dipped galvanized wire.)

Make the square top of the filter box so that it covers the upper edges of the box's sides and can be easily removed. Then cut in its center a round hole slightly smaller than 4 inches in diameter. File the hole's edges so that a 4-inch-diameter can (such as a coffee can with its top and bottom cut out) fits **snugly** in this hole. To connect the can securely and airtight, first use waterproof construction adhesive or epoxy, and then tape. (If construction adhesive or epoxy is not available, cut a 2-1/2-inch-diameter hole in the center of the bottom of the 4-inch-diameter can. Then make radial cuts spaced about one-half inch apart, out to the full diameter of the can. Bend these tabs outward 180 degrees, preparatory to tacking them with small tacks to the bottom of the filter box top. Tape airtight.)

So that the top of the filter box can be easily removed, tape it onto its box. A roll of duct tape should be kept with the filter box and pump at all times.

To connect the filter box to the shelter's air-intake pipe, the best widely available air duct is the inexpensive, 4-inch-diameter flexible duct used with clothes dryers.



Homemade Filter To Fit On Plywood Double-Action Piston Pump, and To Be Connected to a 4-Inch-Diameter Air-Intake Pipe.

Filter Materials

Furnace or air-conditioner dust filters, those made of oiled fiberglass fibers, will remove practically all but the very smallest fallout particles. Filters that are sold in box-like housings can easily be installed so that all the pumped air will pass through them, by taping them to the inner sides of the filter box. The illustration shows two plain mats of furnace filter material, each taped around its edges. (If commercial dust filters are not available, bath towel cloth will serve. However, in very dusty areas a cloth filter may become overloaded, thus seriously reducing the rate of airflow much sooner than if an oiled fiber filter is used as a prefilter.)

To filter out most of the tiny particles that may pass through one or more furnace filters, place two thicknesses of bath towel on top of the filter-support made of hardware cloth, and tape them around their edges to the box. See illustration.

Tests by U.S. Army specialists have shown that filtering air through two thicknesses of bath towel removes about 85 percent of even microscopic aerosols as small as 1 to 5 microns in diameter. (See "Emergency Respiratory Protection Against Radiological and Biological Aerosols", by H. G. Guyton et al., A.M.A. Archives of Industrial Health, Vol. 20, July through Dec. 1959.) This is the size of most infective aerosols used in biological warfare. In most of an area subjected to a biological attack, if 85 percent of this size-range of infective aerosols and practically all larger particles are removed, then most persons breathing this filtered air will not receive enough infective agents to infect and sicken them.

Persons who are especially desirous of protecting their shelter's occupants against biological warfare aerosols, but who can not afford or obtain expensive High Efficiency Particulate Air filters (HEPA filters), should consider using disposable pleated air filters that meet official ASHRAE standards. One 2-in. pleated air filter, measuring 19-1/2 x 19-1/2 in., will remove over 90 percent of particles in the 1.0-5.0 micron range, yet when clean its resistance to an airflow of 200 cfm is only about 0.2 in. water gauge (about 0.007 psi). Its cost is about twice that of a good ordinary furnace filter of the same size. However, it has approximately three times the life of a standard panel type filter before becoming overloaded. Disposable pleated air filters are available in larger cities.

USE

The illustrated homemade filter has such low resistance to airflow that, when up to about 200 cfm is being pumped through it by a Plywood Double-Action Piston Pump, the air volume is decreased by only about 10 percent, as compared to the volume pumped with no filter in the ventilation system. With a homemade Plywood Double-Action Piston Pump, up to approximately 200 cfm can be pumped through this filter even when the total difference in air pressure (caused by the ventilation pipes, a dirty filter, etc. that restrict airflow) is high, about 5 inches water gauge (0.18 psi).

Even if the United States suffers an all-out Soviet attack, only a small part of its area will be subjected to blast effects severe enough to injure the occupants of fallout shelters. (Fallout shelters are not designed to withstand blast, but especially typical earth-covered ones afford consequential blast protection.) In contrast, an installed filter, unless protected by an efficient blast valve, will be wrecked by a quite low-pressure blast wave that comes down its open air-intake pipe —even if the small part of the blast wave that would enter the shelter room through its open ventilation pipes is not nearly powerful enough to injure the shelter occupants. Thus unprotected installed filters will be wrecked in an area several times as large as the area in which occupants of fallout shelters will be injured by blast.

To be sure of having a filter in good condition, you can:

1. Make and keep in your shelter an extra complete filter, ready to replace your installed filter if it is damaged, or if it becomes overloaded with dust and its resistance to airflow becomes too high. Furthermore, if your filter is installed in your shelter room and becomes so radioactive with retained fallout particles that it is delivering a consequential radiation dose to shelter occupants, it is advantageous to be able to remove it, pitch it out, and install a replacement filter. (To be able to supply your shelter with unfiltered air in peacetime or after the end of consequential fallout danger, you should make and keep ready a duct with appropriate fittings to connect your pump directly to its air-intake pipe.)

2. If you have only one filter, do not install it before you need to filter the air supply. Connect your pump directly to the air-intake pipe, using an appropriate duct and fittings. Then before the attack and before the arrival of fallout (revealed by your fallout-monitoring instrument), keep your shelter well ventilated with unfiltered air. Whether or not your filter is installed, stop ventilating your shelter for a few hours while heavy fallout is being deposited outside — unless heat-humidity conditions become unbearable. If before shelter ventilation is stopped the shelter air does not contain an abnormally high concentration of carbon dioxide, then no outdoor air need be supplied for about 5 hours to prevent building up too high a concentration of respiratory carbon dioxide — provided there is about 70 cubic feet of shelter-room volume for each occupant.

AN ENCOURAGING REMINDER

Persons making preparations to improve their chances of surviving an all-out attack should realize that if the United States is hit with warheads the sizes of those in the 1987 Soviet intercontinental arsenal, the fallout particles of critical concern will be much larger than the extremely small particles (1 to 5 microns in diameter) which are not completely removed by this filter. Fallout particles this small produced by large nuclear explosions do not fall to the ground for many days to months after the nuclear explosions, by which time they have become much less radioactive. Essentially all of the larger particles can be removed merely by filtering the air through a few thicknesses of bath towel cloth.

Appendix D
Expedient Blast Shelters

INCREASING IMPORTANCE

The majority of urban and suburban Americans would need blast shelters to avoid death or injury if they did not evacuate before an all-out nuclear attack. As nuclear arsenals continue to grow, an increasing majority would need the protection of blast shelters. In an attack on militarily relevant targets, as much as 5% of the total area of the 48 states could be subjected to blast damage severe enough to destroy or damage homes — depending on the number of warheads assigned to each hard target, weapon reliability, etc. If blast shelters affording protection up to the 15-pounds-per-square-inch (15 psi) overpressure range were available to everybody and were occupied at the time of attack, the great majority of the occupants would survive all blast, fire, and radiation effects in the blast areas subjected to less than 15-psi blast effects.

Fifteen-psi blast shelters will survive as close as about 1.5 miles from ground zero of a 1-megaton surface burst, and about 2.3 miles from ground zero or a 1-megaton air burst. Except in high-density urban areas where the air supply openings and exits of shelters are all too likely to be covered with blast-hurled debris, the area in which people inside good earth-covered 15-psi blast shelters would be killed would be only about 1/6th as large as the area in which most people sheltered in typical American homes probably would die from blast and fire effects alone.

Blast tests have indicated that the Small-Pole Shelter (the most blast-resistant of the earth-covered expedient shelters described in Appendix A) should enable its occupants to survive up to the 50-psi overpressure range — if built with the blast-resistant and radiation-protective features described in following sections, and if located outside an urban area. Calculations show that this earth-covered expedient blast shelter also would give adequate protection at the 50-psi blast overpressure range against the intense initial nuclear radiation that is emitted from the fireball of a 1-megaton explosion. However, to make this shelter (see page 258) provide adequate protection against the even more intense initial nuclear radiation that would reach the 50-psi overpressure range from the fireball of a 500-kiloton or smaller explosion, it should have at least 6 feet of earth cover and additional cans of water should be kept ready to be placed in the horizontal parts of the entryways promptly after the shelter is occupied.

The life-saving potential of well designed, well built blast shelters is a demonstrated fact. Millions of Americans living in high-risk areas would be able to build expedient blast shelters within only a few days—provided they were given field-tested instructions, had made some preparations before the crisis arose, had a few days of recognized warning, and during the crisis were motivated by the President. The following information is given in the hope of encouraging more Americans to make preparations for blast protection. Also, it may serve to increase the number who realize the need for *permanent* blast shelters in high-risk blast areas.

Some informed citizens—particularly those who live near large cities or in their outer suburbs—may choose to build earth-covered expedient blast shelters in their backyards, rather than to evacuate. Going into a strange area and trying to build or find good shelter and other essentials of life would entail risks that many people might hesitate to take, particularly if they live outside the probable areas of severe blast damage. For such citizens, the best decision might be to stay at home, build earth-covered expedient blast shelters, supply them with the essentials for long occupancy, and remain with their possessions.

The following descriptions of the characteristics and components of expedient blast shelters should enable many readers to use locally available materials to provide at least 15-psi blast protection. Pre-crisis preparations are essential, as well as the ability to work very hard for two to four days. (Field-tested instructions are not yet available; to date only workers who were supervised have built expedient blast shelters.[5])

PRACTICALITY OF EXPEDIENT BLAST SHELTERS

At Hiroshima and Nagasaki, simple wood-framed shelters with about 3 feet of earth over wooden roofs were undamaged by blast effects in areas where substantial buildings were demolished.[4]

Figure D.1 shows a Hiroshima shelter that people with hand tools could build in a day, if poles or timber were available. This shelter withstood blast and fire at an overpressure range of about 65 psi. Its narrow room and a 3-foot-thick earth cover brought about effective earth arching; this kept its yielding wooden frame from being broken.

Fig. D.1. A small, earth-covered backyard shelter with a crude wooden frame—undamaged, although only 300 yards from ground zero at Hiroshima.

Although the shelter itself was undamaged, its occupants would have been fatally injured because the shelter had no blast door. The combined effect of blast waves, excessive pressure, blast wind, and burns from extremely hot dust blown into the shelter (the popcorning effect) and from the heated air would have killed the occupants. For people to survive in areas of severe blast, their shelters must have strong blast doors.

In nuclear weapons tests in the Nevada desert, box-like shelters built of lumber and covered with sandy earth were structurally undamaged by 10- to 15-psi blast effects. However, none had blast doors, so occupants of these open shelters would have been injured by blast effects and burned as a result of the popcorning effect. Furthermore, blast winds blew away much of the dry, sandy earth mounded over the shelters for shielding; this resulted in inadequate protection against fallout radiation.

Twelve different types of expedient shelters were blast-tested by Oak Ridge National Laboratory during three of Defense Nuclear Agency's blast tests.[5] Two of these tests each involved the detonation of a million pounds or more of conventional explosive; air-blast effects equivalent to those from a 1-kiloton nuclear surface burst were produced by these chemical explosions.

Several of these shelters had expedient blast doors which were closed during the tests. Figure D.2 shows the undamaged interior of the best expedient blast shelter tested prior to 1978, an improved version of the Small-Pole Shelter described in Appendix A. Its two heavy plywood blast doors excluded practically all blast effects; the pressure inside rose only to 1.5 psi—an overpressure not nearly high enough to break eardrums. The only damage was to the expedient shelter-ventilating pump (a KAP) in the stoop-in entryway. Two men worked about 5 minutes to replace the 4 flap-valves that were blown loose.

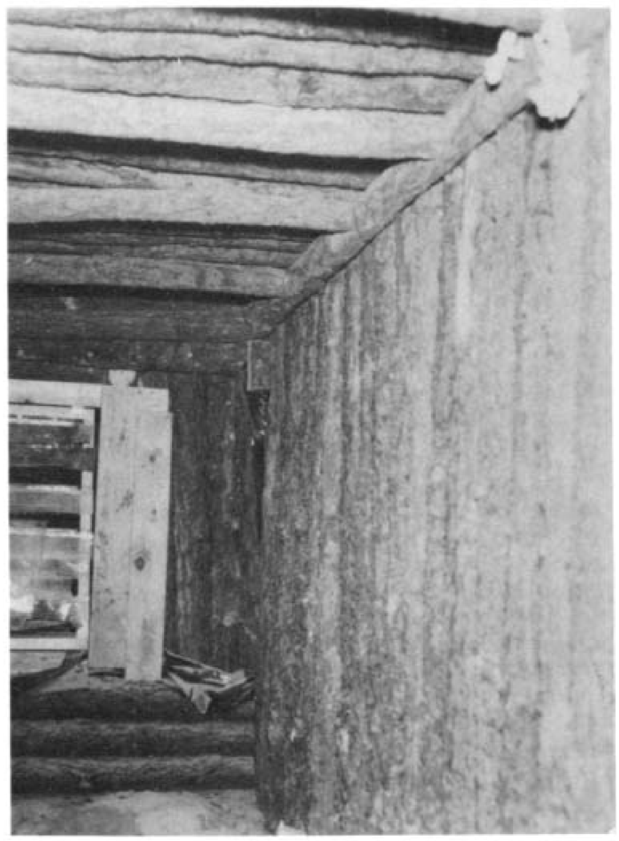


Fig. D.2. Undamaged interior of a Small-Pole Shelter after blast testing at the 53-psi overpressure range. Large buildings would have been completely demolished.

When blast-tested at 5-psi overpressure, not even the weakest covered-trench shelters with unsupported earth walls (described in Appendix A) were damaged structurally. However, if the covering earth were sandy and dry and if it were exposed to the blast winds of a megaton explosion at the 5-psi overpressure range, so much earth would be blown away that the shelter would give insufficient protection against fallout radiation. Much of the **dry,** shielding earth mounded over some of the aboveground shelters was, in fact, removed by the blast winds of these relatively small test explosions, even at the lower overpressure ranges at which homes would be wrecked. In contrast, in blast tests where the steeply mounded earth was damp, little blast-wind erosion resulted. (The reader should remember that even if shelters without blast doors are undamaged, the occupants are likely to suffer injuries.)

CONSTRUCTION PRINCIPLES

Millions of Americans—if given good instructions, strong motivation, and several days to work—should be able to build blast shelters with materials found in many rural areas and suburban neighborhoods. During a crisis, yard trees could be cut down for poles and sticks, and a garage or part of a house could be torn down for lumber. Many average citizens could build expedient blast shelters if they learn to:

- **Utilize earth arching by making a yielding shelter.** The remarkable protection that earth arching gives to those parts of a shelter designed to use it is illustrated by Fig. D.3.

This picture shows the unbroken roof of a 4-foot-wide Pole-Covered Trench Shelter that was built in rock-like soil and blast tested where the blast pressure outside was 53 psi. Its strong blast doors prevented the blast wave from entering. Without the protection of earth arching that developed in the 5 feet of earth cover over the yielding roof poles, the poles would have been broken like straws. In contrast, the ground shock and earth pressure produced by 1-kiloton blast effects almost completely collapsed the unsupported, rock-like earth walls.

Fig. D.3. Effective earth arching in the earth covering of this 4-ft-wide Pole-Covered Trench Shelter prevented a single pole from being broken by blast forces that exerted a downward force of 53 psi (over $3^1/_2$ tons per square foot) on the overlying earth.

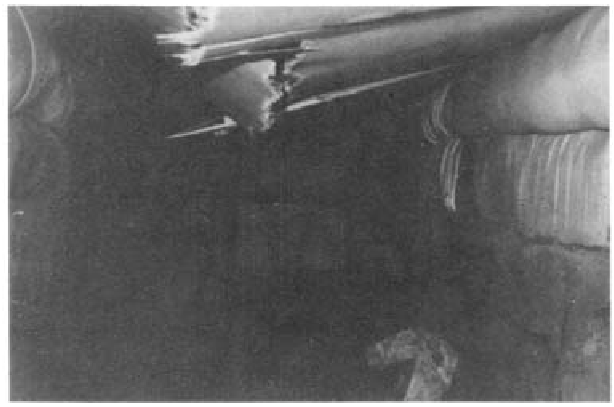


Fig. D.4. Post-blast interior of an Aboveground, Door-Covered Shelter that survived 1-kiloton blast effects at the 5.8-psi overpressure range. The shelter walls were made of bedsheets containing earth, as described in Appendix A.

Figure D.4 also indicates the effectiveness of earth arching. This photo shows the roof of a small, earth-covered fallout shelter, as it appeared after surviving blast effects severe enough to demolish most homes. The roof was made of light, hollow-core, interior doors and looks as though it had been completely broken. In fact, only the lower sheets of $^1/_8$-inch-thick veneer of the hollow-core interior doors were broken. (These breaks were caused by a faulty construction procedure—a front-end loader had dumped several tons of earth onto the uncovered doors.) The upper $^1/_8$-inch-thick sheets of veneer were bowed downward, unbroken, until an earth arch formed in the 2-foot-thick earth covering and prevented the thin sheets from being broken. Earth arching also prevented this roof from being smashed in by blast overpressure that exerted a pressure of 5.8 psi (835 pounds per square foot) on the surface of the earth mounded over this open shelter. (See Appendix A for details of construction.)

- **Make shelters with the minimum practical ceiling height and width.** Most of the narrow covered-trench shelters used by tens of thousands of Londoners during the World War II blitz were built with only $4\frac{1}{2}$-foot ceilings, to maximize blast protection and minimize high water-table problems. These shelters were found to be among the safest for protection against nearby explosions. The Chinese also have a good understanding of this design principle and skillfully utilize the protection provided by earth arching. A Chinese civil defense handbook states: "... the height and width of tunnel shelters should be kept to the minimum required to accommodate the sheltering requirements," and "The thicker the protective layer of earth, the greater the ability to resist blast waves."[21]

- **Shore earth walls to prevent their caving in as a result of ground shock and earth pressure.** Most unshored (that is, unsupported) earth walls are partially collapsed by ground shock at much lower blast overpressures than those at which a flexible roof protected by earth arching is damaged. Figure D.5 is a picture of a seated dummy taken by a high-speed movie camera mounted inside an unshored, Pole-Covered Trench Shelter of the Russian type tested at the 20-psi range. (A second dummy was obscured by blast-torn curtains made of blankets.) The shelter had an open stairway entryway, positioned at right angles to the stand-up-height trench and facing away from the targeted "city" so as to minimize the entry of blast waves and blast wind.

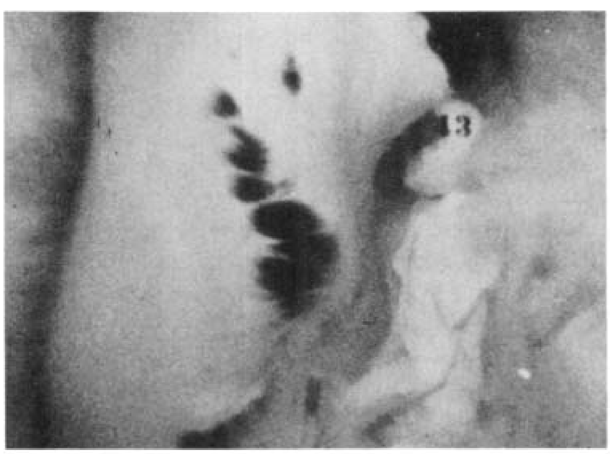


Fig. D.5. A dummy in an unshored Pole-Covered Trench Shelter as it is struck by collapsing rock-like earth walls. The photo also shows the shelter's blanket-curtains as they are torn and blown into the shelter by the 180-mph blast wind. (Immediately after this photo was taken, the dummies were hit by the airborne blast wave and blast wind. Outside, the blast wind peaked at about 490 mph.)

Figure D.6 is a post-blast view of the essentially undamaged earth-covered roof poles and the disastrously collapsed, unshored shelter walls of the Russian shelter tested at 20 psi.[21] Russian civil defense books state that unshored fallout shelters do not survive closer to the blast than the 7-psi overpressure range. This limitation was confirmed by an identical shelter tested at 7 psi; parts of its unshored walls were quite badly collapsed by the ground shock from an explosion producing merely 1-kiloton blast effects.

Fig. D.6. Dummies after ground shock from 1-kiloton blast effects at the 20-psi range had collapsed the rock-like walls of a hardened desert soil called caliche. The dummies' steel "bones" and "joints" prevented them from being knocked down and buried. The fallen caliche all around them kept them from being blown over by the air blast wave and 180-mph blast wind that followed.

Unsupported earth walls should be sloped as much as practical. The length and strength of available roofing material should be considered and, in order to attain effective earth arching, the thickness of the earth cover should be **at least** half as great as the distance between the edges of the trench.

The stability of the earth determines the proper method for shoring the walls of a trench shelter. Methods for shoring both loose, unstable earth and firm, stable earth are described below:

*In loose, unstable earth such as sand, the walls of all underground shelters must be shored. First, an oversized trench must be dug with gently sloping sides. Next, the shoring is built, often as a freestanding, roofless structure. Then earth must be backfilled around the shoring to a level a few inches higher than the uppermost parts of the shoring, as in Fig. D.7. Finally, the roof poles or planks must be placed so that they are supported only by the backfilled earth. Blast tests have indicated that a Pole-Covered Trench Shelter thus proportioned and lightly shored should protect its occupants against disastrous collapse of its walls at overpressure ranges up to 15 psi.

* **In firm, stable earth,** it is best first to dig a trench a few inches wider than 7 feet (the length of the roof poles) and 1 foot deep. Next, dig the part to be shored, down the center of this shallow trench, using the dimensions given for the shoring in Fig. D.7. The trench walls should be sloped and smoothed quite accurately, so that the shoring can be tightened against the earth. If the shoring does not press tightly against the trench walls, large wedges of earth may be jarred loose, hit the shoring, and cause it to collapse.

A different, comparatively simple way to tighten shoring is indicated by Fig. D.8. This sketch shows a 4-pole frame designed to be installed every $2^1/_2$ feet along a trench in stable earth and to be tightened against trench-wall shoring with the same dimensions as those shown in Fig. D.7. Note that the two horizontal brace poles have shallow "V" notches

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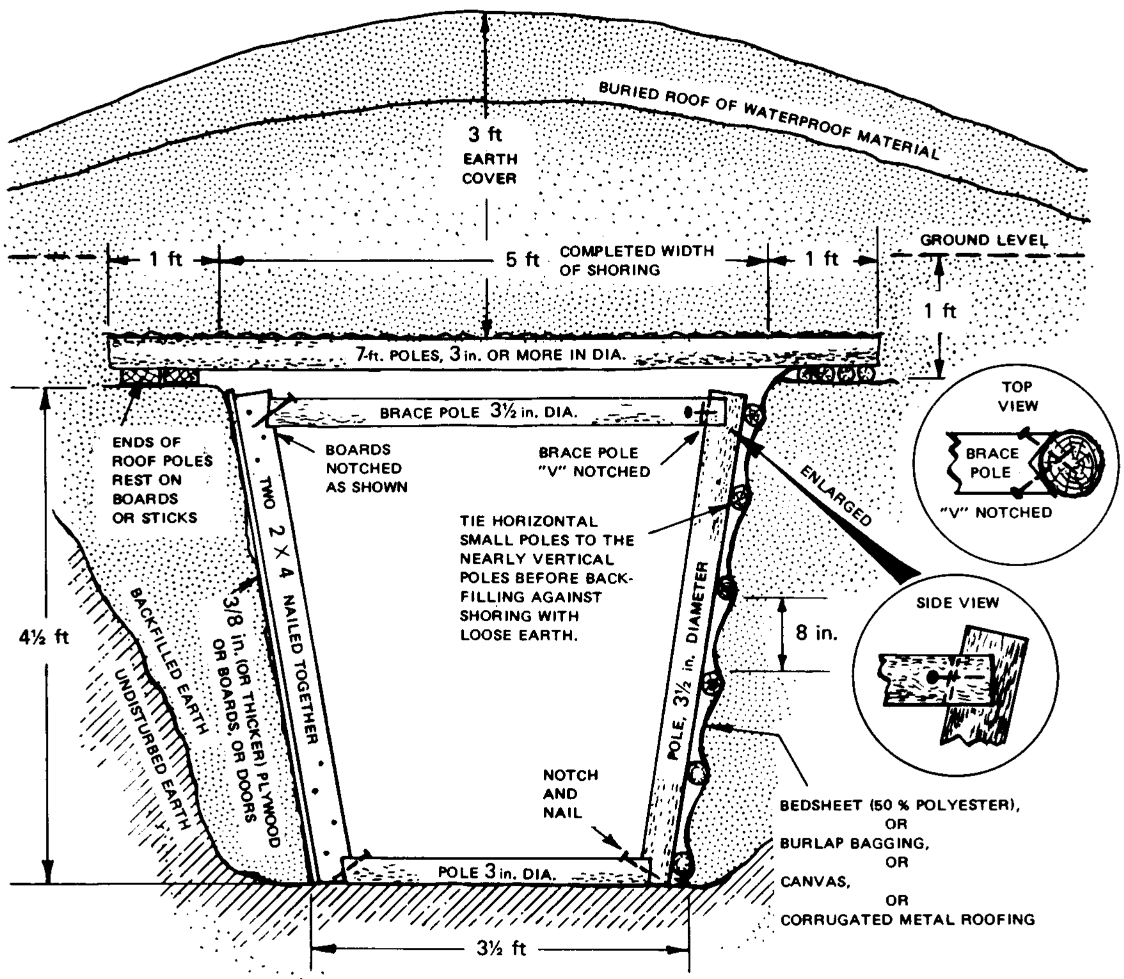

Fig. D.7. An illustration of several ways to shore a trench in unstable earth, using various materials. A 4-piece frame (consisting of 4 poles, or 4 boards, installed as shown above) should be installed every $2^1/_2$ feet along the length of the trench, including the horizontal parts of the entryways. All parts of the shoring should be at least 2 inches below the roof poles, so that the downward forces on the roof will press only on the earth.

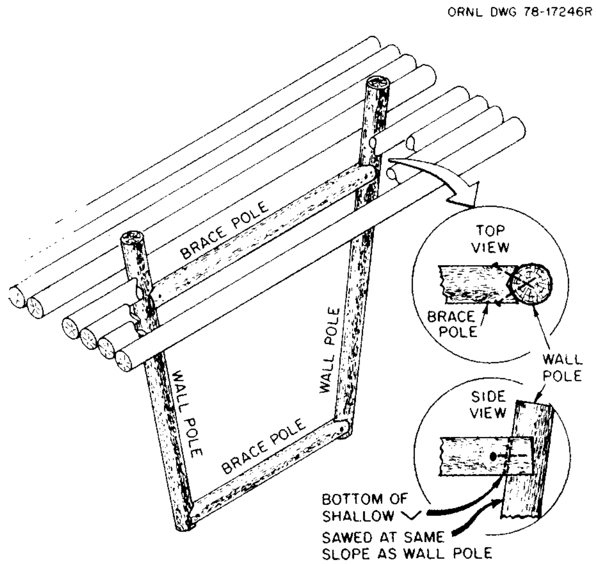

Fig. D.8. A 4-pole frame designed so that it can be tightened against the shoring materials that must press firmly against the walls of a trench dug in stable earth. (In this sketch, the middle sections of three poles have been removed, so that the upper brace pole may be seen more clearly.)

sawed in both ends. If these brace poles are driven downward when positioned as shown, the two wall poles are forced outward against the shoring materials placed between them and the earth walls. An upper brace pole should be cut to the length needed to make it approximately the same height as the roof poles on each side of it (no higher) after the shoring is tightened. Finally, each "V"-notched end should be nailed to its wall pole.

Light, yielding poles can serve simultaneously both to roof and to shore a shelter. A good example is the Chinese "Man" Shelter illustrated in Fig. D.9, requiring comparatively few poles to build.[21] This shelter is too cramped for long occupancy, and its unshored, lower earth walls can be squeezed in by blast pressure. Therefore, it is not recommended if sufficient materials are available for building a well-shored, covered-trench shelter. It is described here primarily to help the reader understand the construction of similarly designed entryways, outlined later in this appendix. The room and the horizontal entryway of the model tested were made of $6^1/_2$-foot poles averaging only 3 inches in diameter. It had two vertical, triangular entries of ORNL design. Each was protected by an expedient triangular blast door made of poles. In Fig. D.9, note the two small horizontal poles at the top of the triangle, one tied inside and the other tied outside the triangle, to hold the wall poles together. Before covering this shelter with earth, a 6-inch-thick covering of small limbs was placed horizontally across the approximately 3-inch-wide spaces between the $6^1/_2$-foot wall poles; the limbs were then covered with bedsheets.

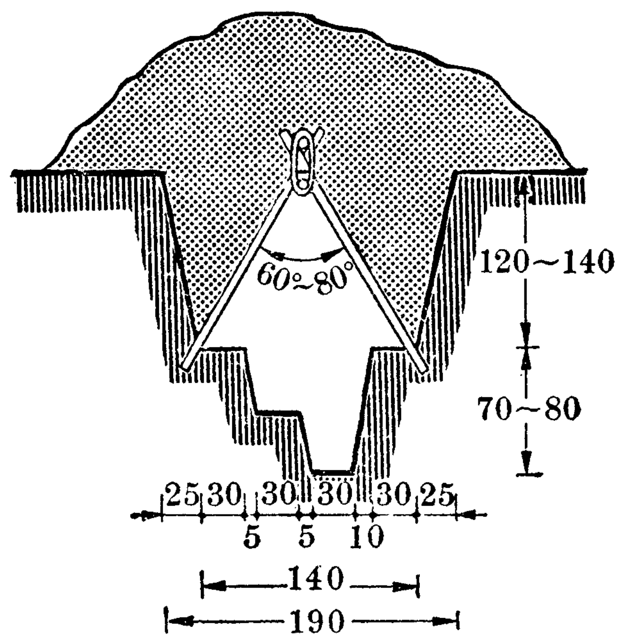

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Fig. D.9. Chinese "Man" Shelter tested at 20 psi, and undamaged because the thin poles yielded and were protected by earth arching. This drawing was taken from a Chinese civil defense manual. The dimensions are in centimeters.

When blast-tested in loose, unstable soil, the unsupported earth walls of the trench below the wall poles were squeezed in. The 12-inch width of the foot trench was reduced to as little as 4 inches by the short-duration forces produced by 0.2-kiloton blast effects at 50 psi. The much longer duration forces of a megaton explosion would be far more damaging to the shelter at lower overpressure ranges, due to destabilizing and squeezing-in unshored earth at depths many feet below ground level.

Calculations based on blast-test findings indicate that the unsupported earth walls of a shelter are likely to fail if the aboveground maximum overpressure is greater than 5 to 7 psi and this overpressure is caused by an explosion that is a megaton or more.

(Most homes would be severely damaged by the 3-psi blast effects from a 1-megaton or larger weapon. This damage would result one mile closer to ground zero of a 1-megaton surface burst than the distance at which the unshored earth walls of some shelters would be collapsed. For a 20-megaton surface burst, the corresponding reduction in distance would be about 2.7 miles.)

- **Build sufficiently long and strong entryways.** Blast shelters need longer horizontal entryways, taller vertical entryways, and thicker earth cover than do most fallout shelters; these are needed primarily for increased protection against high levels of initial nuclear radiation. The entryways of the Small-Pole Shelter described in Appendix A.3 (with the improvements for increased blast protection outlined in the following section of this appendix) afford protection against both blast and radiation up to the 50-psi overpressure range. However, these entryways require straight poles 14 feet long; these may be difficult to find or transport.

In contrast, both the horizontal and the vertical parts of the triangular entry pictured in Figs. D.10, D.11, and D.12 require only small-diameter, short poles. Triangular entries of this type were undamaged by 1-kiloton blast effects at the 20-psi overpressure range[5] and by 0.2-kiloton blast effects at 50 psi. This type of entry and its blast door (also triangular and made of short poles) can be used with a wide variety of expedient blast shelters and should withstand megaton blast effects at 25 psi. Therefore, their construction is described in considerable detail.

* **The horizontal part of a triangular entry:** If the Chinese "Man" Shelter shown in Fig. D.9 is made without excavating the unshored lower trench that forms its earth seats, it will serve as a horizontal, shored crawlway-entry affording blast protection up to at least the 25-psi overpressure range. Two horizontal entries, one at each end of the shelter, should be provided. Each entry should be 10 feet long. This length is needed to reduce the amount of initial nuclear radiation reaching the blast shelter room while assuring adequate through-ventilation. The outer part of such a horizontal entry is pictured in the background of Fig. D.10.

* **The vertical part of a triangular entry:** The *lower section* of the vertical part is made in a similar manner to the horizontal shelter shown in Fig. D.9. Figure D.10 shows $4^1/_2$-foot horizontal poles (1) forming a "V", with one end of each pole laid on top of the adjacent lower pole. The other ends of these poles (1) are pressed against the two pairs of vertical posts (2). (After this photo was taken, the tops of these two pairs of vertical posts were sawed off as

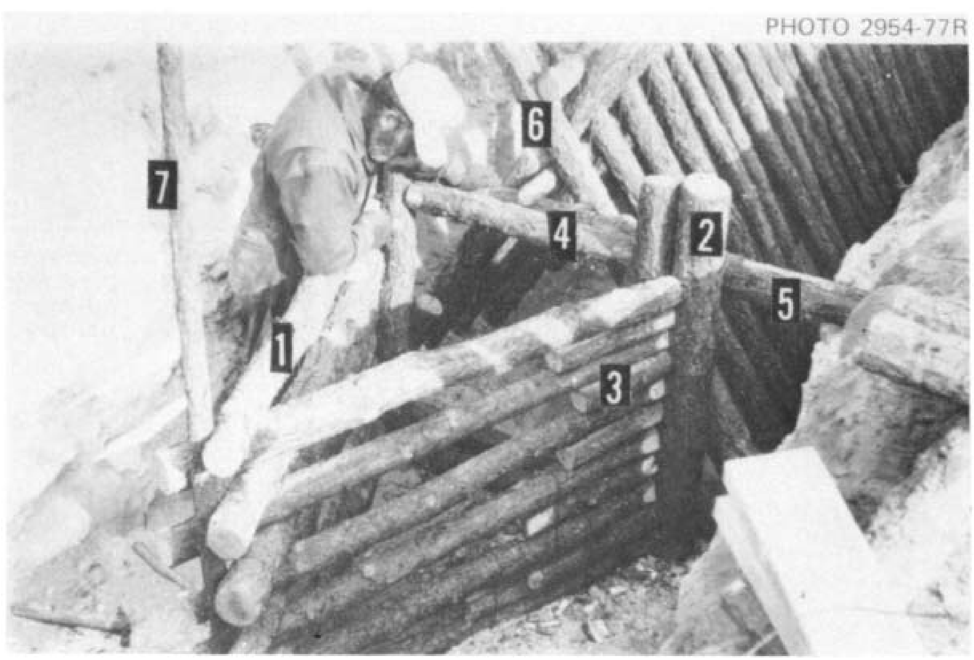

Fig. D.10. Uncompleted lower section of a vertical triangular entry.

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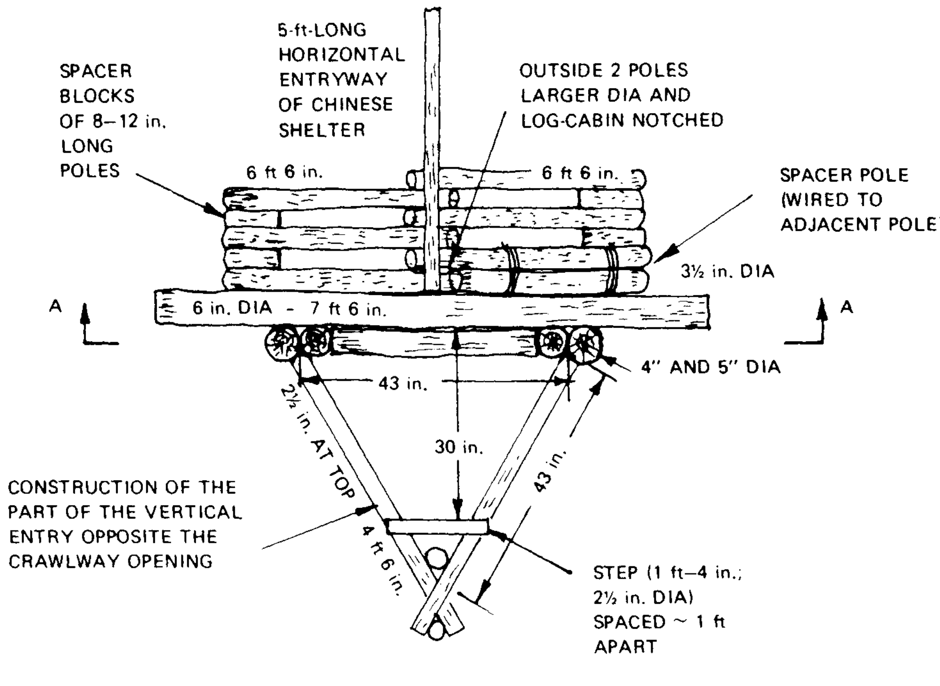
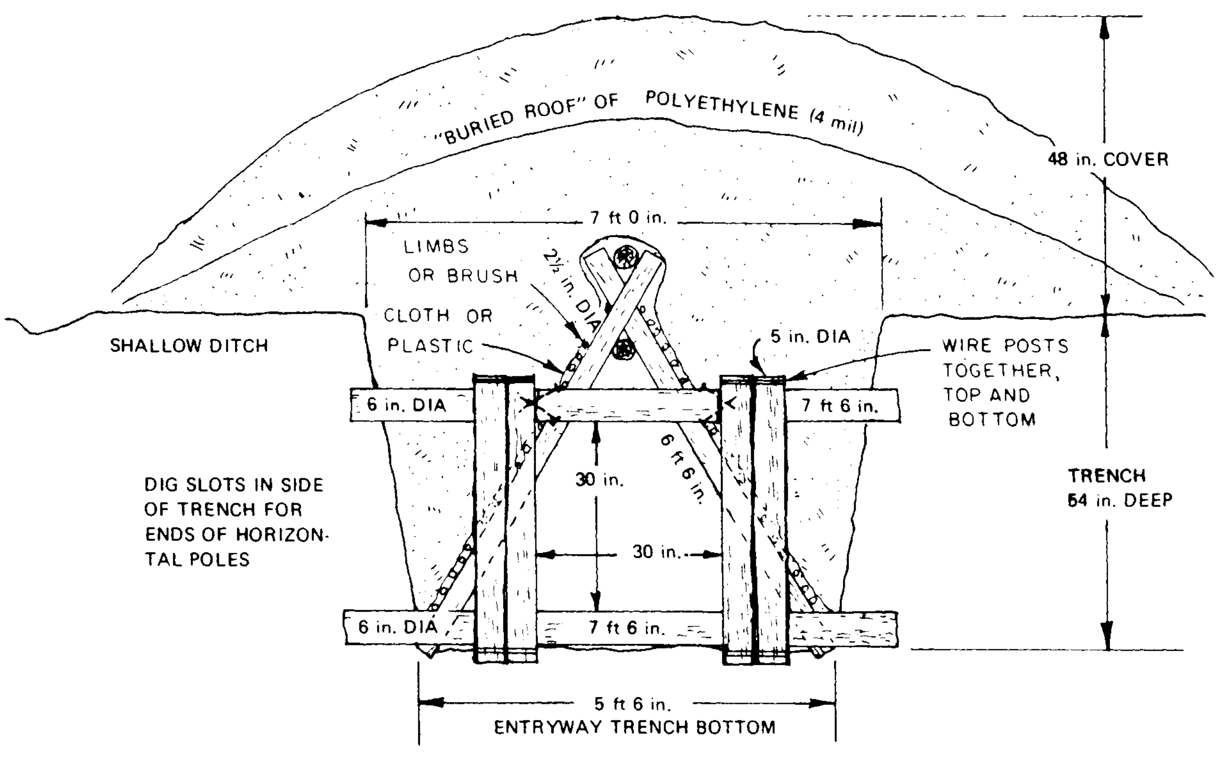


TOP VIEW



VIEW LOOKING INTO SHELTER FROM A–A

Fig. D.11. Lower part of a vertical triangular entry, showing its connection to the horizontal part of the shelter entry.

Fig. D.12. Completed frame of Chinese "Man" Shelter showing its two ORNL-designed entryways (one at each end) and triangular blast doors made of poles. Before covering the triangular vertical entries with earth, tree branches were placed vertically over the sides; the branches then were covered with bedsheets. Horizontal branches, also covered with bedsheets, were laid over the rest of the shelter frame. After being covered with earth, this shelter was subjected to 1-kiloton blast effects. Multiple earth arching over and around this yielding structure prevented both the small poles and the bedsheets from being damaged at 20 psi.

shown in Fig. D.11.) The $4^1/_2$-foot horizontal poles (1) were kept level by the short spacer-poles (3) that were wired or nailed in place.

Each pair of vertical posts (2) was securely wired together at top and bottom. The two pairs were held apart at top and bottom by two horizontal brace-poles toenailed in place to frame the rectangular 30-×30-inch crawlway "doorway" between the vertical entry and the horizontal entry. Only the upper pole (4) of these two 30-inch-long horizontal brace-poles is shown.

The two pairs of vertical posts (2) were positioned so that they pressed against two $7^1/_2$-foot horizontal poles (5); only the uppermost is shown. These in turn pressed against the outermost two poles (6) of the horizontal entry and against the earth in two slot-trenches dug in the sidewalls of the excavation. These two $7^1/_2$-foot poles (5) should be at least 6 inches in diameter.

Additional details of the lower section of this vertical triangular entry are given in Fig. D.11. If horizontal poles considerably larger in diameter than those illustrated are used, fewer poles are required and strength is increased. However, the space inside the entry is decreased unless the larger-diameter horizontal poles that form the "V" are made longer than $4^1/_2$ feet.

As shown on the left in Fig. D.10, a small, vertical pole (7) was placed in the small "V" between the outer ends of the horizontal poles that form the lower section of the vertical entry. After this photo was taken, a second small, vertical pole was positioned in the adjacent large "V", inside the entry. These two poles (7) were then tightly wired together so as to make a strong, somewhat yielding, outer-corner connection of the horizontal poles (1)—in the same way that the tops of the side-wall poles of the Chinese "Man" Shelter are bound together.

The **upper section** of the vertical part of this entry (the section above the tops of the two pairs of vertical posts shown in Fig. D.10 and Fig. D.11) is made by overlapping the ends of its nearly horizontal poles (Fig. D.12). These poles [marked with a (1) in Fig. D.10] were each 4 feet 6 inches long and varied uniformly in diameter from about $2^1/_2$ inches just above the two pairs of wired-together posts, to 4-inch diameters just below the triangular door frame of poles. The triangular-shaped blast door was hinged to and closed against this door frame. The hinges were strips cut from worn auto tires, to be described shortly.

The upper section is formed by laying poles in a triangular pattern, ends crossing at the angles, with large ends and small ends placed so that the poles are as nearly horizontal as is practical. Each of its three corners is held together by strong wires that tightly bind an outside and an inside small vertical pole, in the same manner as the top of the Chinese "Man" Shelter (shown in Fig. D.9) is secured. (Instead of No. 9 soft steel wire, rope or twisted strips of strong fabric could be used.)

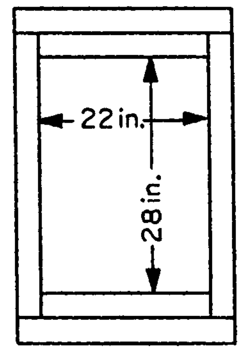
Before starting to install the upper section of a vertical triangular entry, the three outermost of the six small vertical poles that will hold the three corners together should be connected temporarily with three small horizontal poles. Connect them at the height of the door frame planned for the triangular blast door, and space them so as to be the same size as this door frame.

Next, all the horizontal poles should be laid out on the ground in the order of their increasing diameters. The triangular entry then should be started with the smallest poles at the base, with increasingly large-diameter poles used toward the top—so that the three pairs of small vertical poles will press securely against all the horizontal side poles of the entry.

To prevent the negative overpressure ("suction") phase of the blast from yanking out and carrying away the blast door and the upper part of the vertical entry to which it is hinged, the uppermost 4 or 5 horizontal poles of each of the three sides of the vertical entry should be wired or tied securely together. Rope or strips of strong cloth can be used if strong wire is not available.

Before placing earth around this lightly constructed blast-protective entry, the vertical walls must be covered to a thickness of about 6 inches with a yielding, crushable covering of limbs, brush, or innerspring mattresses. Limbs or brush should be placed in three layers, with the innermost layer at right angles to the underlying poles. The yielding thickness then is covered with strong cloth, such as 50% dacron bedsheets, or two thicknesses of 4-mil polyethylene film. This outermost covering keeps loose earth or sand from filling spaces inside the yielding layer or running into the entry. Thus protected, this vertical entry should be undamaged by 25-psi blast effects of megaton weapons.

A vertical blast-protective entry can also be made like a strong box, using 2-inch-thick boards. Such entries afford blast protection up to 50 psi if made as small as shown here and protected with yielding materials such as a 6-inch-thick layer of brush covered with strong cloth.



- **Install blast doors** to keep out airborne blast waves, blast wind, overpressure, blast-borne debris, burning-hot dust and air, and fallout.

A fast-rising overpressure of as little as 5 psi will break some people's eardrums. At overpressures of 15 to 20 psi, 50% of the people who are exposed will have their eardrums broken. However, persons near a shelter wall may have their eardrums broken by somewhat less than half of these unreflected overpressures. (Any wall may reflect blast waves and greatly increase overpressures near it.) Broken eardrums are not serious in normal times, but after a nuclear attack this injury is likely to be far more dangerous to persons in crowded shelters without effective medical treatment. Lung damage, that can result from overpressures as low as 10 to 12 psi, would also be more serious under post-attack conditions.

A blast door must withstand blast waves and overpressure. Not only must the door itself be sufficiently strong to withstand forces at least as great as those which the shelter will survive, but in addition the door frame and the entranceway walls must be equally as strong. The expedient blast door pictured in Fig. D.13 was made of rough boards, each a full 2 inches thick. It had a continuous row of hinges made of 18-inch-long strips cut from the treads of worn car tires.

The strips were nailed to the vertical poles on one side of the vertical entry. These and other details of construction are shown in Fig. D.14. Although the two center boards were badly cracked by the shock wave and overpressure at the 17-psi range, the door

Fig. D.13. Blast door surrounded by 4 blast-protector logs that were notched and nailed together. The wet, mounded soil had been compacted by the blast but not blown away.

pictured in Fig. D.13 afforded good protection against all blast effects from a surface explosion of a million pounds of TNT. In Fig. D.14, note the *essential,* strong tie-down attachment of the wires at the bottom of the vertical entry, to prevent the blast door from being yanked open by the negative pressure ("suction") that follows the overpressure.

Blast doors must be protected against reflected pressures from blast waves that could strike an edge of an unprotected door and tear it off its hinges. Note the blast-protector logs installed around the door pictured in Fig. D.14. When the door was closed, the tops of these four logs were about 2 inches higher than the door, thus protecting its edges on all sides.

The closed door must be prevented from rebounding like a spring and opening a fraction of a second after being bowed down by overpressure, or from being opened and perhaps torn off its hinges by the partial vacuum ("suction") that follows the overpressure phase. Figure D.14 gives the details of such a hold-down system for a blast door. Note that near the bottom of the vertical entry the 6 strong wires must encircle a horizontal pole that is flattened on one side and nailed to the vertical wall poles with at least a dozen 6-inch (60-penny) nails. Blast tests up to the 53-psi overpressure range have proved that this hold-down system works.[5]

Figure D.15 shows a blast door made of 5 thicknesses of $^3/_4$-inch exterior plywood, well glued and nailed together with $4^1/_2$-in. nails at 4-in. spacings. This door was protected by 4 blast-protector logs, each 8 feet long and about 8 inches in diameter. The logs were notched, nailed together, and surrounded with earth. For protection against ignition by the thermal pulse from an explosion, exposed wood and rubber should be coated with thick whitewash (slaked lime) or mud, or covered with aluminum foil.

An equally strong blast door and the door base upon which it closes can be made of poles. If poles are fresh-cut, they are easy to work with ax and saw. Figure D.16 shows the best blast-tested design. This door also had a continuous row of hinges made from worn auto tire treads. The pole to which the hinges were attached was 7 inches in diameter after peeling and had been flattened on its top and outer sides. The two other poles of the equal-sided triangle were 8 inches in diameter and had been flattened with an ax on the bottom, top, and inner sides. The three poles were each 55 inches long. They were notched and spiked together with 60-penny nails so that the door would close snugly on its similarly constructed base made of three stout poles. Other poles, at least 7 inches in diameter before being hewn so that they would fit together snugly, were nailed side-by-side on top of the three outer poles.

Many Americans have axes and would be able to cut poles, but not many know how to use an ax to hew flat, square sides on a pole or log. This easily acquired skill is illustrated by Fig. D.17. The worker should first fasten the pole down by nailing two small poles to it and to other logs on the ground. Figure D.17 shows a pole thus secured. When hewing a flat side, the worker stands with his legs spread far apart, and repeatedly moves his feet so that he can look almost straight down at where his ax head strikes. First, vertical cuts with a *sharp* ax are made about 3 or 4 inches apart and at angles of about 45° to the surface of the pole, for the length of the pole. These multiple cuts should be made almost as deep as is needed to produce a flat side of the desired width. Then the worker, again beginning at the starting end, should cut off long strips, producing a flat side.

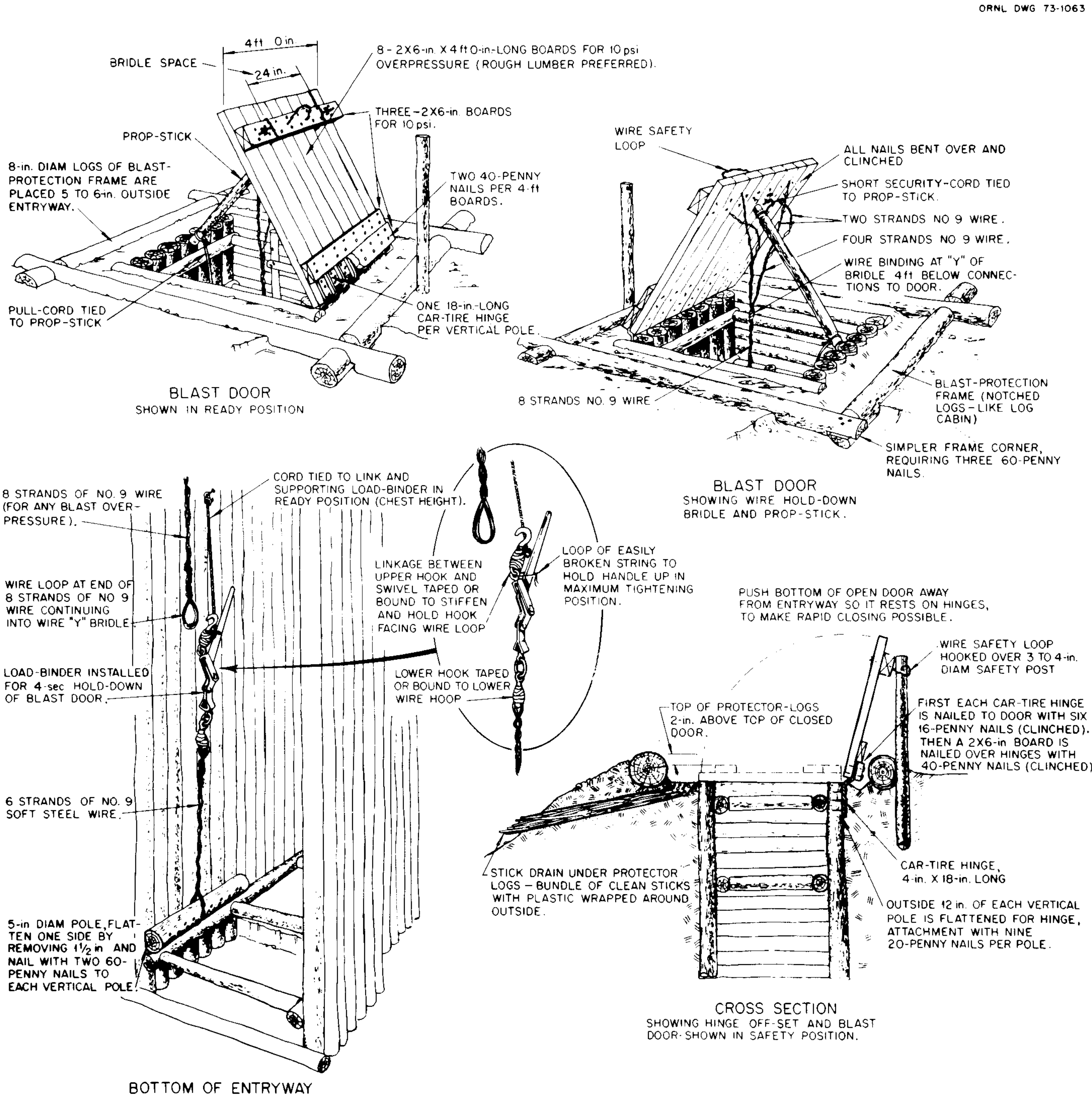


Fig. D.14. Expedient blast door that can be closed and secured in 4 seconds. Four seconds would be too little time if the shelter is at the 15-psi overpressure range from a 550-kiloton or smaller warhead — typical of the 1987 Soviet ICBM arsenal. (See the last paragraph on page 255.) However, this door closure is still the best blast-tested expedient means to secure a closed blast door.

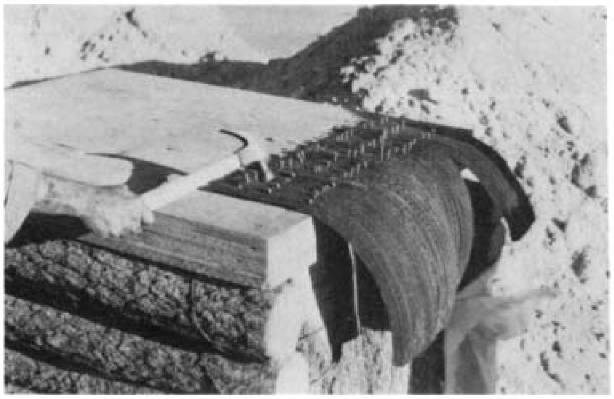


Fig. D.15. Tire-strip hinges nailed to an expedient, 4-inch-thick blast door made of plywood, designed to withstand 50-psi blast effects of very large weapons and undamaged by blast at the 53-psi range.

Fig. D.16. Blast-tested triangular blast door made of hand-hewn pine poles, notched and nailed together. This door closed on a triangular pole base that is concealed in this photo by two of the three blast-protector logs that also withstood 53-psi blast effects.

Fig. D.17. Hewing flat sides on a pole with a sharp ax.

To hew a second flat side at right angles to the first side, rotate the pole 90°, secure it again, and repeat—as pictured in Fig. D.17.

- **Provide blast closures for an adequate ventilation system.** The following two expedient closure systems permit adequate volumes of ventilating air to be pumped through a shelter:

1. **Install two blast doors,** one on each end of the shelter, designed to be left open until the extremely bright light from a large blast is seen. Figure D.14 shows a door held open by a prop-stick that can be yanked away by the attached pull-cord. While propped open, one blast door serves as an extremely low-resistance air-intake opening, and the other serves as an air-exhaust opening. A large KAP can pump air at the rate of several thousand cubic feet per minute through such open doors.

When an attack is expected, each pull-cord should be held by a shelter occupant who stays ready at all times to yank out the prop-stick as soon as he sees the light of an explosion. After the door has fallen closed, the loop at the end of its wire bridle is close to the upper hook of the load-binder and at the same height (Fig. D.14). The person who closes the door should quickly hook the upper hook of the load-binder into the wire loop and pull down on the handle of the load-binder. The door will then be tightly shut. (Sources during an emergency would be the millions of load-binders owned by truckers and farmers.)

At distances from a large explosion where blast wave and overpressure effects are not destructive enough to smash most good expedient blast shelters, there is enough time between the instant the light of the explosion is seen and the arrival of its blast wave for an alert person to shut and securely fasten a well-designed blast door. The smaller the explosion and the greater the overpressure range, the shorter the warning time. Thus at the 15-psi overpressure range from a 1-megaton surface burst (1.5 miles), the blast wave arrives about 2.8 seconds after the light; whereas at the 10-psi overpressure range from a 1-megaton surface burst (1.9 miles), the blast wave arrives about 4.5 seconds after the light. For a 20-megaton surface burst, the warning time at the 15-psi range is about 8 seconds, and at the 30-psi overpressure range, about 4 seconds. Experiments have shown that even people who react quite slowly can close and secure this door within 4 seconds after seeing a spotlight shine on the door without warning.

2. **Build a vertical air shaft next to the outermost side of each vertical entry, with an Overlapping-Flaps Blast Valve** (see Fig. D.18) connecting each entry to its air shaft, as shown in Fig. D.19. These air shafts and blast valves permit forced ventilation to be maintained when the two blast doors are closed. Figure D.18 illustrates the construction of a fast-closing expedient blast valve, a design that was undamaged by the 65-psi shock wave and other effects produced by the explosion of a million pounds of TNT. When blast-tested in a shock-tube at 100-psi, the flaps were undamaged; they closed in 6/1000 of a second (0.006 sec.). This is as fast as the best factory-made blast valves close.

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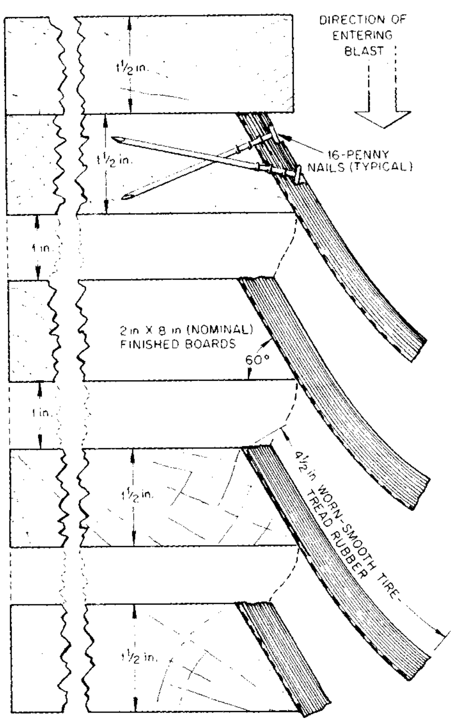

Fig. D.18. Overlapping-Flaps Blast Valve, made of boards, plywood, and strips cut from the treads of worn car tires.

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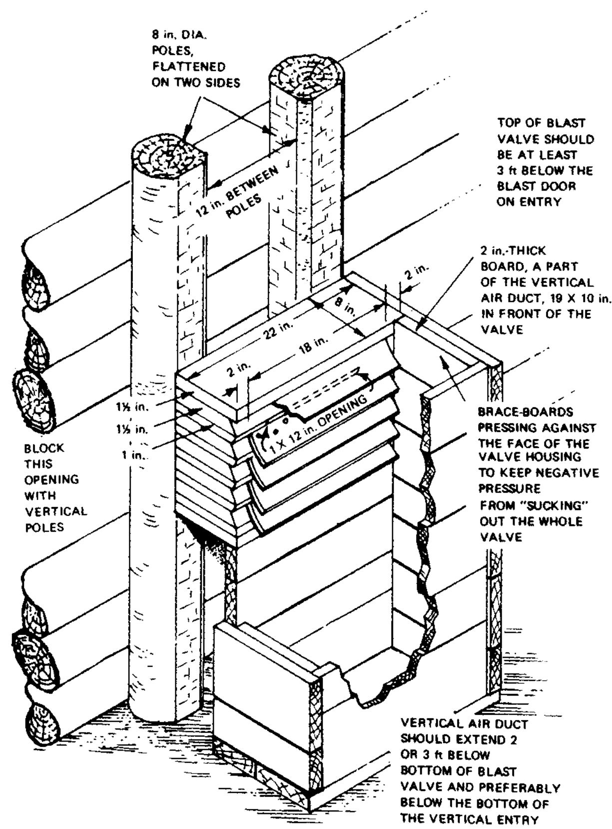

Fig. D.19. Installation of a 50-psi Overlapping-Flaps Blast Valve in such a way that it will not be blown into a shelter by the blast overpressure, nor pulled out by the following negative pressure ("suction") phase.

To withstand 50 psi, the load-bearing "2-inch" boards (actually 1½ inches thick) of the valve should be at least 6 inches wide, if the 1-in.-high air openings are each made 12 in. wide, measured between two vertical poles of a shelter entry. See Fig. D.19, that gives the dimensions of a valve that has been blast tested.[5] Note that there are 5 inches of solid wood at each end of each 1-in.-high air opening. If there are 5 such air openings to a valve, a properly installed KAP (Appendix B) can pump air at about 125 cubic feet per minute (125 cfm) through a shelter equipped with such valves. This ventilation rate is ample for at least 40 people in cold weather. Except in hot and humid weather, a constant air supply of about 10 cfm per shelter occupant is enough to maintain tolerable conditions during continuous shelter occupancy for many days.

If a factory-made blower capable of pumping more than 100 cfm is available, use it. Such a hand-operated blower can pump against much higher air flow resistances than a KAP can. It can pump its full-rated volume of outdoor air through a shelter equipped with two Overlapping-Flaps Blast Valves, one at each end of the shelter and each with only 2 air openings—providing a total of 24 square inches of openings per valve. Equally or more effective is a homemakeable Plywood Double-Action Piston Pump, made and operated as described in Appendix E.

Remember that a pressure of 7200 pounds pushes against each square foot of the exposed face of a blast valve when it is subjected to a 50-psi blast overpressure. Also keep in mind that the "suction" that follows can exert an outwardly directed force of up to 700 pounds per square foot on the valve face and can yank it out of position unless it is securely installed. Figure D.19 shows how to securely install a blast valve. (Merely nailing a blast valve in its opening will not enable it to withstand severe blast forces.)

Note in Figure D.19 that an opening is shown between the back edge of the uppermost board of the Overlapping-Flaps Blast Valve and the adjacent horizontal pole of the vertical entry. Both this opening and the similar opening next to the lowermost board of the Blast Valve should be closed off with a stout board, to prevent blast from going through these openings and on into a vertical entry and the shelter room.

The top of an air shaft should be a few inches higher than the earth piled around it, as are the tops of the vertical entries of the Small-Pole Shelter illustrated in Figure A.3.1 on page 174. To minimize the amount of rain that may fall into an air shaft, a shed-like, open-sided miniature roof should be placed over it, a few inches above its top. The roof can be lightly constructed, since it will be blown away by a severe blast.

- **Minimize aboveground construction and the mounding of shielding earth.** At high overpressure ranges, the shock wave and the blast-wind drag can wreck an aboveground shelter entry. For example, the 5-ft-high earth mound over a shelter built with its pole roof at ground level was moved enough by 1-kiloton air-blast effects at the 53-psi overpressure range to break one of the poles of a blast-door frame. The forces of a 1-megaton explosion at the same overpressure range would have operated 10 times as long, and probably would have smashed the vertical entryways of this shelter. Whenever practical, a blast shelter should be built far enough belowground so that the top of its shielding earth cover is at ground level. Avoiding aboveground construction and earth mounds also greatly reduces the chances of damage from blast-hurled, heavy debris, such as tree trunks and pieces of buildings.

Dry earth, steeply mounded over a shelter which is subjected to blast winds from a big explosion, will be mostly blown away. However, blast-wind "scouring" of **wet** earth is negligible. The blast winds from a 1-kiloton explosion at the 31-psi overpressure range scoured away 17 inches of **dry,** sandy soil mounded at a slope of 32°.

If it is impractical to build a blast shelter with its roof belowground, good protection can be attained by mounding even dry earth at slopes not steeper than 10°.

- **Provide adequate shielding against initial nuclear radiation.** Good expedient blast shelters require a greater thickness of earth cover than is needed on good fallout shelters, for these reasons:

  * Blast shelters should also protect against initial nuclear radiation emitted by the fireball. This radiation is reduced by half when it penetrates about 5 inches of packed earth (as compared to a halving-thickness of only about 3½ inches of earth against radiation from fallout).
  * The initial radiation, in some areas where good blast shelters will survive, can be much greater than the fallout radiation is likely to be.
  * Initial nuclear radiation that comes through entryways is more difficult to attenuate (reduce) than fallout radiation. Therefore, longer entryways or additional right-angle turns must be provided.

For these reasons, good blast shelters should be covered with at least 4 ft of well-packed, average-weight earth, or 5 ft of unpacked or light earth. (A 3-ft thickness gives excellent protection against radiation from fallout.)

A 50-PSI SMALL-POLE SHELTER

This expedient blast shelter is described in detail to enable the reader to build this model. The details will help him better understand the design principles of other expedient blast shelters that are capable of preventing injuries from blast effects severe enough to destroy all ordinary buildings and kill the occupants. Blast tests and calculations have indicated that the Small-Pole Shelter described and illustrated in Appendix A.3 will afford protection against all weapon effects at overpressure ranges up to 50 psi that are produced by an explosion of 1 megaton, or *larger,* provided the shelter is:

- Made with horizontal entryways each with ceilings no higher than 7 ft, 2 in., no wider than 3 ft, and each at least 10 ft long—to lessen the radiation coming through the entries (see Fig. D.20). Lower and narrower entryways would give better protection but would increase the time required for entry.
- Constructed with a floor of poles that are 4 in. or more in diameter, laid side-by-side, with the wall poles resting on the floor poles. The ground shock and earth pressures at a depth of 10 ft or more resulting from an overpressure on the surface of more than about 35 psi, if caused by a large explosion, may destabilize and squeeze earth upward into the shelter through an unprotected earth floor. The Small-Pole Shelter described in Appendix A.3 has an earth floor.
- Installed in an excavation about 13 feet deep, with the shelter's vertical entrances appropriately increased in height so that the blast doors are only about one foot above the original ground level.

To prevent possibly life-endangering cave-in of the 13-foot-deep trench that was dug for the blast testing of this model shelter, the trench walls were sloped about 45 degrees. The shelter was built as a braced, free-standing structure, and then covered. During a crisis it would be impractical to safely excavate a deep trench with steeply sloping walls and then safely build a shelter in it. A 13-foot-deep trench is usually too deep to dig by hand—especially since to dig it with safely sloping walls requires the removal of a large amount of earth.

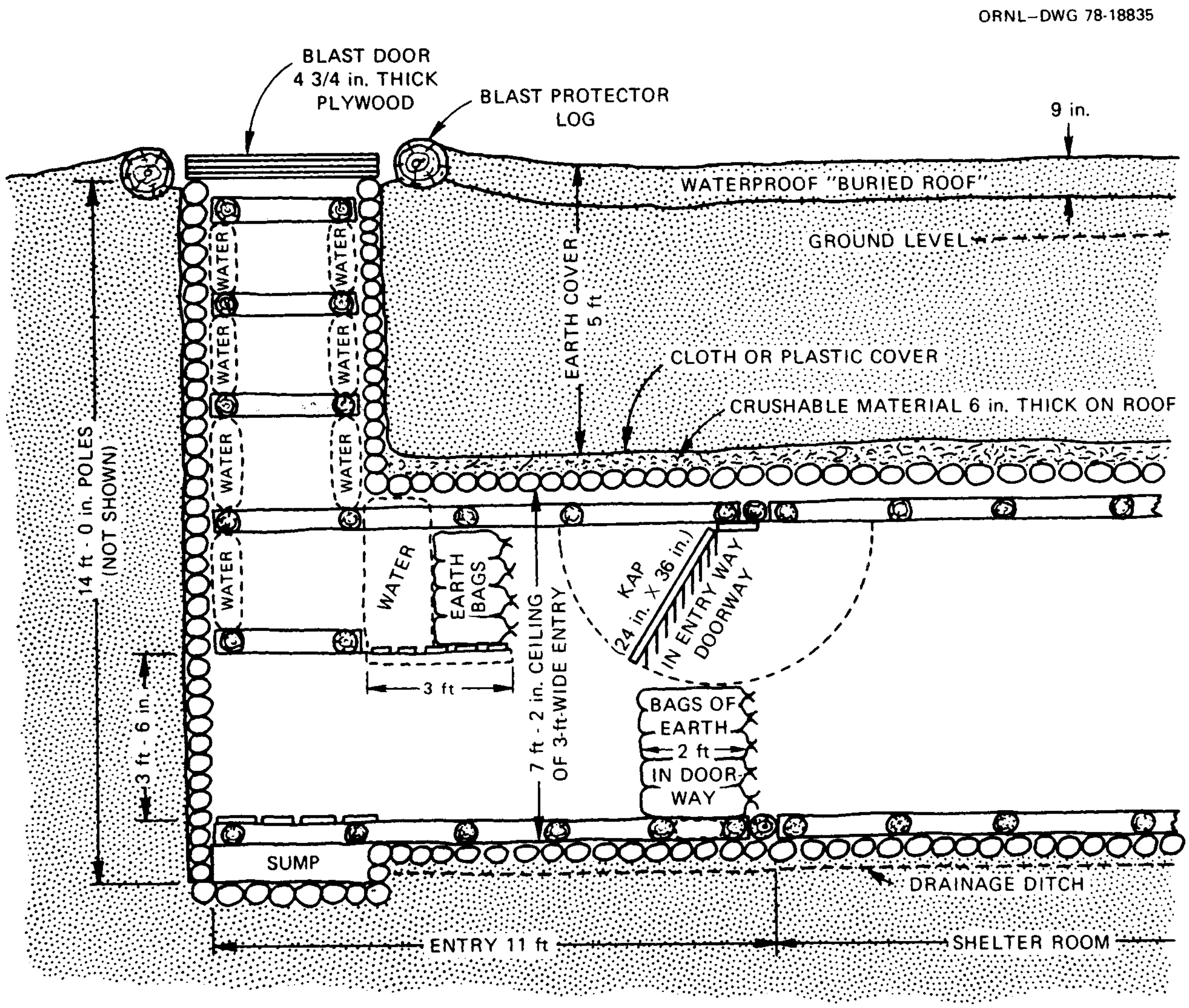

Fig. D.20. Entryway of Small-Pole Blast Shelter shielded against initial nuclear radiation. This sketch is a simplified vertical section through the centerline of one end of the shelter.

- Made with 4 rectangular horizontal braces in each vertical entry, in addition to the ends of the two long, ladder-like braces. The detailed drawings in Appendix A show such braces. The lowest rectangular brace should be positioned $3^1/_2$ feet above the flooring at the bottom of the vertical entry (see Fig. D.20).

- Equipped with blast doors each made of 5 sheets of $^3/_4$-inch exterior plywood (see Fig. D.15) bonded with resin glue and nailed together with $4^1/_2$ in. nails. The nails should be driven on 4-in. spacings and their protruding ends should be clinched (bent over). The blast doors must be secured against being yanked open by negative pressure ("suction") by securing them with a strong wire bridle (see Fig. D.14), and with the lower, fixed wire strongly connected near the bottom of the entry to all of the vertical poles on one side, as shown in Fig. D.14.

- Provided with an adequate ventilation pump and with ventilation openings protected against blast by expedient blast-valves (Fig. D.18) installed in the vertical entries as shown in Fig. D.19, to protect the air-intake and the air-exhaust openings. (Ventilation openings should be as far as practical from buildings and combustible materials. Manually closed ventilation openings are NOT effective at the 50-psi overpressure range of most weapons, because there is insufficient time to close them between the arrival of the warning light from the explosion and the arrival of the blast wave.)

- Made with the roof poles covered by a yielding layer of brush or limbs about 6 inches thick, or of innerspring mattresses. This yielding layer in turn should be covered with bedsheets or other strong cloth, to increase the effectiveness of protective earth arching. Brush or limbs should be laid in 3 layers with sticks of the middle layer perpendicular to those of the other two layers.

- Covered with 5 feet of earth, sloped no steeper than 10°.

- Provided with additional shielding materials in the entryways, as shown in Fig. D.20. Such shielding would be needed to prevent occupants from receiving possibly incapacitating or fatal doses of initial nuclear radiation through the entryways at the 50-psi overpressure range, if the shelter is subjected to the effects of a weapon that is one megaton, *or larger,* in explosive yield.

Damp earth serves better for neutron shielding material than dry earth and can be substituted for water as shielding material if sufficient water containers are not available. (At the 50-psi overpressure range from explosions *smaller* than one megaton, the entry and shielding shown in Fig. D.20 may not provide adequate protection against initial nuclear radiation.)

When the shelter is readied for rapid occupancy, the shelter-ventilating KAP is secured against the ceiling, and the bags of earth in the doorway (under the KAP) are removed. Persons entering the shelter would stoop to go under the platform adjacent to the vertical entry. This platform is attached to vertical wall-poles of the horizontal entry and supports shielding water and earth. When all except the person who will shut and secure the blast door are inside the shelter room, occupants should quickly begin to place bags of earth in the doorway. When the attack has begun, the whole doorway can be closed with bags of earth or other dense objects until ventilation is necessary.

The entries of other types of blast shelters can be shielded in similar ways.

- Protected against fire by being built sufficiently distant from buildings and flammable vegetation and by having its exposed wood covered. For maximum expedient protection against ignition by the thermal radiation from a large explosion, all exposed wood should be free of bark, coated with wet mud or damp slaked lime (whitewash), and covered with aluminum sheet metal or foil to reflect heat. (Most of the thermal radiation from an explosion that was 1 megaton or larger would reach the 50-psi overpressure range after the blast wave had arrived and had torn the expedient protective coverings from the wood. However, as has been observed in megaton nuclear weapon tests, the dust cloud first produced by the popcorning effect and later by the blast winds would screen solid wood near the ground so effectively against thermal radiation that it would not be ignited, provided it had been initially protected as described above.)

PRECAUTIONS FOR OCCUPANTS OF BLAST SHELTERS

Although a well constructed blast shelter may be undamaged at quite high overpressure ranges, its occupants may be injured or killed as a result of rapid ground motions that move the whole shelter several inches in a few thousandths of a second. Rapid ground motions are not likely to cause serious injuries unless the shelter is in an area subjected to 30-psi or greater blast effects. To prevent possible injury, when the occupants of high-protection blast shelters are expecting attack they should avoid:

- Having their heads close to the ceiling. The "air slap" of the air-blast wave may push down the earth and an undamaged shelter much more rapidly than a person can fall. If one's head were to be only a few inches from the ceiling, a fractured skull could result.

- Leaning against a wall, because it may move very rapidly, horizontally as well as vertically.

- Sitting or standing on the floor, because ground shock may cause the whole shelter (including the floor) to rise very fast and injure persons sitting or standing on the floor. The safest thing to do is to sit or lie in a securely suspended, strong hammock or chair, or on thick foam rubber such as that of a mattress, or on a pile of small branches.

In dry areas or in a dry expedient shelter, ground shock may produce choking dust. Therefore, shelter occupants should be prepared to cover their faces with towels or other cloth, or put on a mask. If an attack is expected, they should keep such protective items within easy reach.

B903.2.1.2-24

VCC: [F] 903.2.1.2, SECTION 202

Proponents: Richard Gordon, representing Hanover County (rtgordon@hanovercounty.gov)

2021 Virginia Construction Code

Revise as follows:

[F] 903.2.1.2 Group A-2. An *automatic sprinkler system* shall be provided throughout stories containing Group A-2 occupancies and throughout all stories from the Group A-2 occupancy to and including the *levels of exit discharge* serving that occupancy where one of the following conditions exists:

1. The *fire area* exceeds 5,000 square feet (464 m^2).
2. The fire area has an occupant load of 100 or ~~more in *night clubs* or 300 or more in other Group A-2occupancies.~~ more.
3. The *fire area* is located on a floor other than a *level of exit discharge* serving such occupancies.

Delete without substitution:

~~**NIGHT CLUB.** Any *building* in which the main use is a place of public assembly that provides exhibition, performance or other forms of entertainment; serves alcoholic beverages; and provides music and space for dancing.~~

Reason Statement:

Virginia has historically modified IBC section 903.2.1.2 to allow sprinkler systems to be omitted in A-2 occupancies for up to 300 people, with the exception of night clubs. While this modification potentially reduces cost for restaurants and similar uses with occupant loads between 100 and 300, the night club definition has caused confusion and misapplication by code officials. Some code officials apply the night club definition to banquet halls and other spaces that have the components listed in the definition: alcohol, music and a space for dancing. Other code officials have evaluated use in a broader sense and assigned an occupancy classification based on the actual use of the space. The result is that in some localities, a banquet hall with between 100 and 300 occupants requires automatic sprinklers, while in others, sprinklers are not required until the occupant load exceeds 300.

By eliminating the exception, the inconsistency in application of 903.2.1.2 will be eliminated, and the VCC will be more consistent with the ICC. The night club definition can be removed as the distinction between night clubs and other A-2 uses is no longer pertinent.

Cost Impact: The code change proposal will increase the cost

This proposal will increase the cost of construction for A-2 occupancies with occupant loads between 100 and 300 as these spaces will now require automatic sprinklers.

B907.2.1.1-24

VCC: 907.2.1.1; IBC: [F] 907.5.2.1.2

Proponents: Richard Gordon, representing Hanover County (rtgordon@hanovercounty.gov)

2021 Virginia Construction Code

Revise as follows:

907.2.1.1 System initiation in Group A occupancies with an occupant load of 1,000 or more~~ and in certain night clubs~~. Activation of the fire alarm in Group A occupancies with an occupant load of 1,000 or more~~ and in *night clubs* with an occupant load of 300 or more~~ shall initiate a signal using an emergency voice and alarm communications system in accordance with Section 907.5.2.2 .

> **Exception:** Where approved, the prerecorded announcement is allowed to be manually deactivated for a period of time, not to exceed 3 minutes, for the sole purpose of allowing a live voice announcement from an approved, constantly attended location.

2024 International Building Code

Revise as follows:

[F] 907.5.2.1.2 Maximum sound pressure. The total sound pressure level produced by combining the ambient sound pressure level with all audible notification appliances operating shall not exceed 110 dBA at the minimum hearing distance from the audible appliance. Where the average ambient noise in Group A occupancies exceeds 105 dBA, a system arranged to stop or reduce ambient noise shall be provided in accordance with NFPA 72. In all other occupancies, where the average ambient noise is greater than 105 dBA, *visible alarm notification appliances* shall be provided in accordance with NFPA 72 and *audible alarm notification appliances* shall not be required.

Reason Statement: The current VCC provisions differentiate night clubs from other A occupancies, both with respect to sprinkler provisions and alarm annunciation, but the concerns with night clubs are also present in other A occupancies. Theaters, arenas and other A occupancies often have high ambient noise levels and distracting lighting that could obscure notification appliances. This proposal attempts to address those concerns in all A occupancies by requiring a system to reduce or turn off sources of ambient noise, while also eliminating the need to treat night clubs differently. This proposal is submitted in conjunction with a proposal to require automatic sprinklers in all A-2 occupancies with an occupant load greater than 100.

Cost Impact: The code change proposal will increase the cost

Night clubs with 300-1000 occupants would no longer need a voice alarm system, but would likely require a system to reduce or eliminate sources of ambient noise. Other A occupancies where ambient noise exceeds 105 dBA would also incur the cost of this system.

B1006.3.4-24

IBC: TABLE 1006.3.4(1), 1006.3.4.2 (New)

Proponents: Lyle Solla-Yates, representing Charlottesville Planning Commission (lyle.sollayates@gmail.com)

2024 International Building Code

Revise as follows:

TABLE 1006.3.4(1) STORIES AND OCCUPIABLE ROOFS WITH ONE EXIT OR ACCESS TO ONE EXIT FOR R-2 OCCUPANCIES

STORY	OCCUPANCY	MAXIMUM NUMBER OF DWELLING UNITS	MAXIMUM EXIT ACCESS TRAVEL DISTANCE
Basement, first, second, ~~or~~ third, or fourth story above grade plane and occupiable roofs over the first, ~~or~~ second, or third story above grade plane	R-2[a, b, c, d]	4 dwelling units	125 feet
~~Fourth~~Fifth story above grade plane and higher	NP	NA	NA

For SI: 1 foot = 304.8 mm.

NP = Not Permitted.

NA = Not Applicable.

a. Buildings classified as Group R-2 equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2 and provided with emergency escape and rescue openings in accordance with Section 1031.

b. This table is used for Group R-2 occupancies consisting of dwelling units. For Group R-2 occupancies consisting of sleeping units, use Table 1006.3.4(2).

c. This table is for occupiable roofs accessed through and serving individual dwelling units in Group R-2 occupancies. For Group R-2 occupancies with occupiable roofs that are not accessed through and serving individual units, use Table 1006.3.4(2).

d. 4-story buildings and 3-story buildings with an occupiable roof above the third story shall also comply with Section 1006.3.4.2.

Add new text as follows:

1006.3.4.2 Single exit four-story buildings with Group R-2 dwelling units.. Four-story buildings with a single exit for Group R-2 dwelling units shall comply with Table 1006.3.4(1) and all of the following:1. The net floor area of each floor shall not exceed 4,000 square feet (418.5 m). 2. Openings to the interior exit stairway enclosure shall be limited to those required for exit access into the enclosure from normally occupied spaces, those required for egress from the enclosure, and openings to the exterior. Elevators shall not open into the interior exit stairway enclosure. 3. A manual fire alarm system and automatic smoke detection system that activates the occupant notification system in accordance with Section 907.5 shall be provided. Smoke detectors shall be located in common spaces outside of dwelling units, including but not limited to gathering areas, laundry rooms, mechanical equipment rooms, storage rooms, interior corridors, interior exit stairways, and exit passageways. 4. Regardless of the stairway construction type, automatic sprinkler locations in interior exit stairways shall comply with the requirements of NFPA 13 for combustible stairways. 5. Electrical receptacles shall be prohibited in an interior exit stairway.

Reason Statement: The 2024 International Building Code allows buildings up to three stories of R-2 occupancy to have up to four dwelling units at each story served by a single exit. This proposal acknowledges the rising demand for infill multifamily development and a growing movement in Virginia and across the United States and Canada to modify building codes for this purpose. We recommend enabling a single exit to serve up to four stories of R-2 occupancy above the grade plane.

This language is identical to the modified proposal marked “E24-24-SHAPIRO-MC1”. That language was adapted from codes in Seattle, Honolulu, New York City, and in Western European countries.

Within the United States, Seattle, Honolulu, and New York City have allowed buildings with generally fewer restrictions, to no ill effect or local controversy, and no major fires.

Cost Impact: The code change proposal will decrease the cost

The cost of constructing four story multifamily buildings on small lots will decrease by roughly 7 percent, in line with the reduction in circulation area required.

This size reduction enables multifamily development that would otherwise be physically impossible on the smallest sites, allowing for lower cost site options.

Attached Files

- **2024_RD845-Single-staircase_Advisory_Group_Findings_and_Recommendations_–_November_2024 (1).pdf**
  https://va.cdpaccess.com/proposal/1273/1790/files/download/898/

Glenn Youngkin
Governor

Caren Merrick
Secretary of
Commerce and Trade

COMMONWEALTH of VIRGINIA

DEPARTMENT OF
HOUSING AND COMMUNITY DEVELOPMENT

Bryan W. Horn
Director

November 27, 2024

Memorandum

To: Board of Housing and Community Development
Senator Adam Ebbin, Chair, Senate Committee on General Laws and Technology
Delegate David Bulova, Chair, House Committee on General Laws

From: Single-staircase Advisory Group

RE: Findings and Recommendations

Background

House Bill 368 and Senate Bill 195 (2024) as approved by the General Assembly and signed by the Governor (*Appendix 1*), directed the Board of Housing and Community Development (the Board) to convene a workgroup to provide recommendations for allowing a single stair exit for Group R-2 (multifamily residential) structures up to six stories in height (above grade plane). The legislation required the Single-staircase Advisory Group (Advisory Group) to submit its findings and recommendations to the Board and General Assembly by December 1, 2024. The Advisory Group met three times, and a summary of each meeting is included in the Appendix (*Appendix 2a-c*).

The Advisory Group's efforts consisted of in-person discussion, written testimony, background research, and accepting in-person and written public comments. These efforts were part of a fact-finding exercise that sought to evaluate various considerations related to a potential proposal during the regular development of the Uniform Statewide Building Code (USBC). The Advisory Group operated outside of the normal code development cycle, allowing it to focus on this singular topic in depth.

The Advisory Group did not develop a model proposal to allow a single-stair exit in multifamily residential structures up to six stories, rather, it laid out the many considerations that may need to be taken into account if a proposal comes before the Board. The Advisory Group provided thoughtful analysis of benefits of single-stair construction, the fire safety concerns associated with these structures, and the features of protection that may be needed to keep occupants safe during emergencies.

History

The Advisory Group outlined a brief history of the single-stair issue at the first meeting on September 9, 2024. The Advisory Group reviewed and heard main points from a 2021 code change proposal that had been submitted to the Board for consideration (*Appendix 4a*). This proposal was based on a code change that was approved in Seattle, and the 2018 Seattle Code (*Appendix 4b*) served as template language. The proposal received a non-consensus recommendation from a code cycle workgroup and was not approved by the Board. In addition to these efforts in Virginia, the Advisory Group noted the International Code Council (ICC) is reviewing similar proposals for allowing single-stair construction above current limits (*Appendix 4c and 5aa*). At the time of this report, ICC code change proposal E24-24 has been through the committee action hearing process, resulting in approval of the proposal by the committee as modified (*Appendix 4d*). Final actions on E24-24 will likely occur during the public comment hearing and online government consensus voting period in 2026. Lastly, the Advisory Group discussed the National Fire Protection Association's (NFPA) single exit stair symposium and expressed interest in the recommendations from authoritative experts on this topic (*Appendix 5a*). The history of this issue demonstrates that the Advisory Group's efforts are not occurring in a vacuum, and the Commonwealth should consider the single-stair issue with these other proposals and recommendations in mind.

Baseline

The Advisory Group found that the primary purpose of the current two-stair exit requirement for buildings over three stories is to provide occupants with an alternate means of egress during an emergency. The Advisory Group found that this is an important safety requirement in the event one of the two staircases (exits) is blocked, congested, compromised, or damaged. There are many other safety requirements in the USBC, and the Advisory Group discussed some general "baseline" provisions to determine what added features of protection may be needed if a building lacked a second stair exit. During the second Advisory Group meeting on October 15, 2024, there was discussion of the following requirements currently in the building code:

- Travel distance to exits
- Fire penetrations
- Type of construction (combustible vs. noncombustible)
- Sprinklers
- Egress width
- Occupant load formula
- Exterior access for fire department
- Elevators

The Advisory Group noted that there is a spectrum and variety of requirements for different buildings captured by the Advisory Group's authorizing legislation ("*Group R-2 occupancies…not more than six stories above grade plane*.") Future workgroups may need to outline in more detail the current requirements in order to determine what additional provisions may need to be added to ensure occupants are safe.

Fire Safety Considerations

A key takeaway from the Advisory Group meetings was that fire safety concerns are the primary reasons for currently not allowing a single-stair exit for multifamily residential structures above three stories. Advisory Group members said that the building code's redundancy in egress options exists for occupant escape and first responder access during emergencies. At four stories and above, Emergency Escape and Rescue Openings (EEROs) start to become technically and functionally infeasible. EEROs are windows or doors that provide occupants a means of escape and rescue. Advisory Group members noted that at four stories and above, there are no requirements for EEROs because these floors not only have a minimum requirement for two exits, but fire service access and rescue may not be practical or possible at that height. The Advisory Group found that at levels at and above four stories, if the only means of egress was blocked/compromised, occupants would have to use "defend in place" strategies, e.g. wait until emergency help arrives to escape. Advisory Group members found that performing emergency response operations in a single stairwell, that is simultaneously being used for occupant escape, negatively impacts rescue and fire suppression efforts.

In addition to concerns raised at the Advisory Group meetings from members associated with fire service organizations, three organizations shared written statements: a letter from the Virginia Professional Fire Fighters (*Appendix 3a*), a joint statement from the International Association of Fire Fighters and Metropolitan Fire Chiefs Association (*Appendix 3b*), and a statement from the National Association of State Fire Marshals (*Appendix 3c*)

Advisory Group members discussed potential (upgraded) fire safety protections when only one stair is present in structures with four to six stories. To compensate for a lack of a second means of egress, all or some of these added protections may make up the elements of a future single-staircase proposal:

- Requiring construction type 1 or 2 (non-combustible materials) for any single-stair building over three stories
- Closer exterior access to building for fire departments
- Capability of fire department (ISO Class 1 rating)
- Wider egress width. Advisory Group discussed a 60-inch requirement. See study on wider egress width in *Appendix 5z*
- Limiting the number of units per floor or net floor area (*Appendix 4d*) to control occupant load
- Limiting and clearly defining occupied floors, roofs, stories, podiums, and grade
- Pressurizing exit stair enclosure to prevent smoke from entering
- Mechanical smoke ventilation systems (*Appendix 5d*)
- Higher sprinkler density above and beyond current requirements
- Early smoke detection in common areas (stairwell itself)
- Special inspections for penetrations of rated assemblies

The Advisory Group discussed in further detail the considerations related to these added fire safety features. These considerations can serve as areas of further research for future workgroups in the building code update cycle to deliberate. Advisory group members emphasized the importance of performing a cost-benefit analysis on these added fire safety protections. The list captures some of the various factors that need to be considered when analyzing a single-stair proposal with the health, safety, and welfare of occupants in mind. Details on each individual consideration is included in the October 15, 2024 meeting summary (*Appendix 2b*).

When considering added protections and requirements, the advisory group finds that the provisions of floor modification E24-MC1 (*Appendix 4d*) may provide a beneficial framework for a future single-staircase code change proposal.

Other Topics Discussed

Benefits - Part of the Advisory Group's fact-finding exercise was outlining the benefits of single-stair construction and the reasons to consider this code change on its merits. Advisory Group members advocated that single-stair buildings are needed to fit more units/living space on small urban lots. Advisory Group members pointed to a section in the City of Charlottesville's Inclusionary Zoning Analysis that highlights parcels of land that would benefit from this development (*Appendix 5e*). The Virginia Zoning Atlas also shows parcels where localities allow taller multifamily development by right, potentially creating opportunities for single-stair construction above current limits to increase housing stock (*Appendix 5bb*). Additional research was shared detailing the benefits of these structures in Oregon (*Appendix 5f*), Massachusetts (*Appendix 5g-h*), Tennessee (Appendix 5i), Minnesota (*Appendix 5j-k*), Montana (*Appendix 5l*), Australia (*Appendix 5q*), Vancouver and across Canada (*Appendix 5m-p*). Examples of single-stair construction in Seattle were also shared (*Appendix 5b-c*).

Advisory Group members found that projects on these small lots would otherwise be financially infeasible if sellable living space was taken up by a second staircase. Advisory Group members reasoned that the current two-stair requirement is limiting housing stock because of the challenges fitting the necessary number of units onto small lots for the project to make financial sense. In addition to financial considerations, Advisory Group members shared additional benefits of single-stair construction and design. These benefits include the flexibility to add more types of multifamily housing, more natural light and ventilation, and the ability to build structures consistent with historically significant architectural design, aiding municipalities in their historical preservation goals. Advisory Group members shared additional articles and reports detailing these benefits (*Appendix 5r-y*). Advisory Group members proposed that added fire safety requirements may not be needed in single-stair structures because of the relative safety of multifamily residential buildings. Advisory Group members pointed to the current fire safety standards and data on fire fatalities in multifamily building (*Appendix 5r-s*).

The American Institute of Architects Virginia shared a written statement that reiterated the benefits of single-stair construction. The statement also supports efforts to further evaluate single-stair proposals (*Appendix 3d*).

Legislating the Building Code – Advisory Group members shared concerns that efforts from the General Assembly to approve a code-change proposal allowing a single-stair exit above current limits may undermine the building code development process in Virginia. Advisory Group members warned that "legislating the building code" does not support Virginia's robust stakeholder-based building code development process.

Recommendations to the Board

The Advisory Group recommends that any proposal to allow a single stair exit above current limits should be considered by the Board during the normal building code development process. The Advisory Group discussed a variety of considerations related to the health, safety, and welfare of occupants for future workgroups to deliberate in more detail. The Advisory Group presents these considerations as a big-picture overview of this issue and a summary of all the different factors that may arise when considering a single-stair exit proposal. The Advisory Group recommends the Board convene a special workgroup during the 2024 building code update cycle to continue discussing this topic, ICC code change proposal E24-24 as modified, and any related proposals.

Appendix

1. Authorizing Legislation - HB360/SB195

2. Meeting Summaries
   a) September 9, 2024
   b) October 15, 2024
   c) November 6, 2024

3. Statements
   a) Virginia Professional Fire Fighters
   b) International Association of Fire Fighters & Metropolitan Fire Chiefs Association
   c) National Association of State Fire Marshals
   d) American Institute of Architects Virginia

4. Proposals
   a) 2021 Proposal Virginia
   b) 2018 Seattle Code
   c) 2024 Proposal ICC
   d) Draft Floor Modification 2024 ICC Proposal E24-24-SHAPIRO-MC1

5. Research and Analysis
   a) National Fire Protection Association (NDPA) - Single Exit Stair Symposium
   b) Single Staircase Examples in Seattle - American Institute of Architects
   c) Single Staircase Example in Seattle - Habitat for Humanity + News article
   d) How Mechanical Smoke Ventilation Systems Work
   e) City of Charlottesville's Inclusionary Zoning Analysis
   f) Benefit analysis for small-footprint apartment buildings in Oregon – Sightline Institute
   g) Could Legalizing Mid-Rise Single-Stair Housing Expand and Improve Housing Supply? – Joint Center for Housing Studies (JCHS) of Harvard University
   h) Legalizing Mid-Rise Single-Stair Housing in Massachusetts – JCHS of Harvard University
   i) Single Stair Design & 2024 Legislation – AIA Tennessee
   j) Single-egress stairway apartment building study – Minnesota
   k) Advocacy Update: Commercial Code TAG Approves Single-Stair Apartments – Housing First Minnesota
   l) Governor's Housing Task Force -Montana
   m) Unlocking livable, resilient, decarbonized housing with Point Access Blocks – Larch Lab for the City of Vancouver
   n) Optimizing Form & Function with Michael Eliason – The Passive House Network
   o) Single Egress Stair Building Designs: Policy and Technical Options Report – British Columbia
   p) The Second Egress: Building a Code Change – Conrad Speckert, McGill University
   q) Australian Apartment Shows How Single Stairs Make Small Buildings Better – Treehugger

r) Single-Stair Construction: New Data on Costs, Benefits, and Outcomes - Pew Charitable Trusts
s) Fire Death Rate Trends: An International Perspective – U.S. Fire Administration
t) Early Zoning and the War on Multifamily Housing – Strong Towns
u) Why we can't build family-sized apartments in North America – Center for Building in North America
v) How to build more family-sized apartments – Niskanen Center
w) The Olympic Village: High-Performance Housing Illegal to Build in the U.S. – Medium
x) Point Access Block Building Design: Options for Building More Single-Stair Apartment Buildings in North America – U.S. Department of Housing and Urban Development
y) Why North America Can't Build Nice Apartments (because of one rule) – Urbanarium For Smart Cities
z) Means of Escape in Residential Buildings
aa) The International Code Council's Role in Code Development and Building Safety – ICC
bb) Virginia Zoning Atlas

VIRGINIA ACTS OF ASSEMBLY -- 2024 SESSION

CHAPTER 384

An Act to direct the Board of Housing and Community Development to convene a stakeholder advisory group to evaluate and recommend revisions to the Uniform Statewide Building Code to permit Group R-2 occupancies to be served by a single exit.

[H 368]

Approved April 4, 2024

Be it enacted by the General Assembly of Virginia:

1. *§ 1. The Board of Housing and Community Development (the Board) shall convene a stakeholder advisory group including fire code officials to evaluate and recommend revisions to the Uniform Statewide Building Code (§ 36-97 et seq. of the Code of Virginia) to permit Group R-2 occupancies to be served by a single exit, provided that the building has not more than six stories above grade plane. The advisory group shall submit its findings and recommendations to the Board and to the Chairmen of the House Committee on General Laws and the Senate Committee on General Laws and Technology no later than December 1, 2024.*

VIRGINIA ACTS OF ASSEMBLY -- 2024 SESSION

CHAPTER 385

An Act to direct the Board of Housing and Community Development to convene a stakeholder advisory group to evaluate and recommend revisions to the Uniform Statewide Building Code to permit Group R-2 occupancies to be served by a single exit.

[S 195]

Approved April 4, 2024

Be it enacted by the General Assembly of Virginia:

1. *§ 1. The Board of Housing and Community Development (the Board) shall convene a stakeholder advisory group including fire code officials to evaluate and recommend revisions to the Uniform Statewide Building Code (§ 36-97 et seq. of the Code of Virginia) to permit Group R-2 occupancies to be served by a single exit, provided that the building has not more than six stories above grade plane. The advisory group shall submit its findings and recommendations to the Board and to the Chairmen of the House Committee on General Laws and the Senate Committee on General Laws and Technology no later than December 1, 2024.*

Meeting Summary
Single-staircase Advisory Group
September 9, 2024
10:00 AM
Virginis Housing Center
4224 Cox Rd, Glen Allen, VA

Advisory Group Members Present:
William Abrahamson, American Institute of Architects Virginia
Hampton Barclay, Private Developer
Eric Cavallo, Private Contractor
Andrew Clark, Home Builders Association of Virginia
Rick Hinson, American Council of Engineering Companies of Virginia
Alex Horowitz, Pew Charitable Trusts
Billy Hux, State Fire Marshal
Jason Laws, Virginia Building and Code Officials Association
Andrew Milliken, Virginia Fire Services Board
Steven Sites, Virginia Fire Services Board
Lyle Solla-Yates, Local Planning Professional
Schuyler Van Valkenburg, Senate of Virginia (16th District)
Dan Willham, Virginia Building and Code Officials Association

DHCD staff attending for all or part of meeting:
Jeff Brown, State Building Codes Office Director
Trisha Lindsey, Policy and Legislative Services Director
Andrew Malloy, Policy Analyst
Paul Messplay, Code and Regulation Specialist
Richard Potts, Code Development and Technical Support Administrator
Chase Sawyer, Policy and Legislative Services Manager

Key Takeaways

- Advisory Group members agree that any findings or recommendations from the Advisory Group should be reviewed and considered during the normal code development process.
- The primary reasons discussed for not allowing a single stair exit for multifamily residential structures above current limits are fire safety concerns.
- Advisory Group members created a preliminary list of topics to be reviewed by the Advisory Group when considering allowing a single-staircase above current limits. The topics relate to fire safety, resident health/safety/welfare, accessibility, and general building code considerations.

Summary

Department of Housing and Community Development (DHCD) staff provided a summary of the purpose of the meeting and introduced the topic before the Single-staircase Advisory Group

(Advisory Group). During the 2024 General Assembly Session, HB368 and SB195 were approved by the General Assembly and signed by the Governor. The identical bills directed the Board of Housing and Community Development (Board) to convene a stakeholder advisory group to provide findings and recommendations for allowing a single stair exit for Group R-2 (multifamily residential) structures up to six stories in height. The Advisory Group is directed to submit its findings and recommendations to the Board and General Assembly by December 1, 2024. DHCD staff emphasized that the Advisory Group is tasked with only making findings of fact and recommendations. The findings of the Advisory Group could then be used by the Board when considering proposals during the normal code development process. DHCD staff further emphasized that the Advisory Group is not a part of the normal code development cycle, rather it serves as an opportunity to discuss this topic in more detail, laying some groundwork for future code cycle workgroups.

The Advisory Group discussed the background and history of the single-staircase proposal. Advisory Group members shared examples of single-staircase construction in other parts of the country such as Seattle, Washington, and New York City, as well as internationally in Europe. The Advisory Group discussed how many single-staircase buildings are being built in these areas; however, there is a lack of information on the prevalence of these structures in the United States. Some Advisory Group members questioned whether single-staircase construction would be used if allowed by the building code. Advisory Group members discussed alternative methods for complying with the current staircase requirements that could also yield similar benefits as allowing a single staircase, such as interlocking stairwells or stairs connected to an elevator lobby with an alternative stairwell only for residents. Advisory Group members also noted that a proposal of this nature related to residential buildings could have implications associated with non-residential building uses.

The Advisory Group discussed the benefits and safety concerns associated with allowing a single staircase for multifamily structures up to six stories. Advisory Group members noted that the current building code, which allows a single exit in multifamily structures up to three stories, creates challenges for builders in some areas due to zoning constraints. Some Advisory Group members shared that single-staircase structures can in some instances be more economically feasible in higher-density localities where lots are small and zoning restrictions prevent larger production-style multifamily development. Advisory Group members reasoned that single-stair structures could be more economically feasible because they allow for additional square footage, more units, and more efficient use of space, which creates more revenue opportunities and higher margins for builders/developers. Some Advisory Group members also suggested that allowing these structures could rehabilitate existing structures and provide opportunities for in-fill units on lots that would otherwise go untouched, which would increase the housing supply, making housing more affordable generally. Advisory Group members acknowledged that additional fire safety measures would be required for single-staircase buildings greater than three stories, including, but not limited to, sprinklers, mechanical smoke ventilation systems, and higher fire-rating building materials.

The Advisory Group discussed concerns that exist related to allowing a single staircase for buildings up to six stories. The reasons for concern shared by Advisory Group members were primarily regarding the health, safety and welfare of residents in addition to the safety of firefighters and other first responders accessing a building with a single staircase during emergencies. Some Advisory Group members noted that one point of entry and exit for firefighters and evacuating residents is a significant concern. Advisory Group members also noted that some city lots do not have adequate fire department access, making the need for at least two means of egress more important. Concerns were also raised that the capabilities and resources of individual fire departments may vary, creating problems of access for fire departments with fewer resources or inadequate equipment. Advisory Group members shared that a reason for allowing a single staircase for up to three stories is because self-evacuation and exterior escape ladders are still options at that height and may not be viable options for taller heights.

There was consensus within the Advisory Group that any proposals or recommendations related to the Uniform Statewide Building Code (USBC) should still go through the standard code development process. Advisory Group members expressed concerns with efforts to "legislate the building code." Advisory Group members suggested establishing a specific workgroup during the next code update cycle related to the single-staircase issue. Additionally, there was consensus that the USBC should still be uniform in nature and not have exceptions or different building requirements for different regions of the Commonwealth.

During public comment, a member of the public spoke in opposition to a single-staircase code change. He said this change would lead to reduced public safety. He expressed concerns that the proposed systems designed to protect residents in single-staircase buildings (i.e. mechanical smoke ventilation) might fail in the future due to maintenance issues. He shared that safety should be the main priority.

Future Considerations

A key takeaway of the meeting was that fire safety concerns are the primary reasons for not allowing a single staircase for multifamily residential structures above current limits. Advisory Group members created a list of topics to consider in more detail at future meetings regarding the proposal to allow a single exit for Group R-2 (multifamily residential) structures up to six stories in height.

- Fire Safety Considerations
    - Building construction/design:
        - Exterior grades; stories at or above grade; podium construction; occupied roofs
        - Construction type; combustible vs non-combustible construction materials
        - Locations and types of fire separations (fire barrier, fire wall, fire partition)
    - Egress:
        - Egress width; exit configuration; exit access; and exit travel distance
        - Egress above ground/patio egress; egress through mixed occupancy

        - External vs. internal stairs
        - Areas of refuge; emergency communications
    - Fire sprinkler and fire alarm requirements
    - Special inspection (IBC Chapter 17) of fire rated assembly penetrations
    - Providing prop alarms on stairway doors
    - Providing smoke control in stairway; skylight technology; pressurization
    - Mixed uses (occupancy classifications)
    - Occupant loads (maximum)
    - Capacity and capability of jurisdiction and fire department(s), including fire apparatus and water availability
    - Firefighter and first responder access to the building (internal and external)
        - Open perimeters
        - Elevator size and type
        - Emergency escape and rescue openings (EERO)
- Other Considerations
    - Cross connection within units
    - Accessibility (non-firefighter)
    - Relative safety for different housing types
    - Benefits

Meeting Summary
Single-staircase Advisory Group
October 15, 2024
10:00 AM
Virginis Housing Center
4222 Cox Rd, Glen Allen, VA

Advisory Group Members Present:
William Abrahamson, American Institute of Architects Virginia
Hampton Barclay, Private Developer
Eric Cavallo, Private Contractor
Ron Clements, Virginia Building and Code Officials Association
Rick Hinson, American Council of Engineering Companies of Virginia
Alex Horowitz, Pew Charitable Trusts
Andrew Milliken, Virginia Fire Services Board
Lyle Solla-Yates, Charlottesville Planning Commission

DHCD staff attending for all or part of meeting:
Jeff Brown, State Building Codes Office Director
Andrew Malloy, Policy Analyst
Florin Moldovan, Code and Regulation Specialist
Richard Potts, Code Development and Technical Support Administrator
Chase Sawyer, Policy and Legislative Services Manager

Key Takeaways

- The Advisory Group discussed in more detail the list of topics to be reviewed when considering allowing a single stair exit in certain structures.
- Advisory Group members discussed additional fire safety measures, above and beyond what is already included in the code for multifamily residential structures above three and up to six stories. Consensus was not reached on which additional fire safety measures would ensure health/safety/welfare of residents in these structures if the second staircase was not required.

Summary

Department of Housing and Community Development (DHCD) staff opened the floor for public comments at the beginning of the second meeting of the Single-staircase Advisory Group (Advisory Group). During public comment, three fire services professionals expressed concerns that a single-staircase structure above three stories would jeopardize the safety of occupants. They said if one exit was lost or blocked during a fire, it would be very difficult to get occupants at higher levels out of the building. They said it would be even more difficult for smaller fire departments with fewer resources to evacuate occupants at high levels. These fire services professionals expressed understanding that the single-stair proposal seeks to address housing affordability, and they urged those in attendance to seek other solutions to lower the cost of housing that do not affect safety. The fire services professionals also expressed opposition to efforts that "legislate the building code" and urged legislators to not move forward proposals like this one that the International Code Council (ICC) has not included in the model codes. They said if a proposal does come before the Board of Housing and Community Development (the Board), additional fire protection features should be added. They asked Advisory Group members to trust the professional advice of those who work in fire safety. They shared that the International Association of Firefighters, the Metropolitan Fire Chiefs Association, and the Virginia Professional Fire Fighters have stated opposition to single-stair construction in large multifamily dwellings.

A private citizen also spoke during public comment and expressed opposition to a single-stair proposal above current limits because of some non-fire related safety concerns. She expressed concerns that handicap residents may not be able to evacuate during all kinds of emergencies. The private citizen said events such as an active shooter, domestic violence, flooding and other natural disasters would put residents at additional risk if there were only one stair/exit for higher levels. She also said single-stair design would create higher density and other problems associated with it such as, public utility challenges (sewer, water, etc.), loss of community (open space), parking challenges, and traffic.

After public comment, DHCD staff provided a brief recap of the takeaways from the first Advisory Group meeting held on September 9, 2024, including the recommendation that any findings or recommendations from the Advisory Group should be reviewed and considered during the normal code development process. Staff outlined the structure of the meeting and pointed to the list of topics for consideration made during the previous meeting. Advisory Group members were prompted to determine if each item listed was an issue worth considering in a future code proposal, fire protection features to potentially include in a future proposal, and/or if there are any noteworthy pieces of research related to each topic that will aid workgroups in the normal code development process.

During the discussion of topics, the Advisory Group recognized that a variety of fire safety protections currently exist in the building code for multifamily structures up to six stories. The Advisory Group noted that these fire safety protections are developed with two staircases in mind when the structure is more than three stories. Advisory Group members discussed fire safety protection features that should be required (added) in order to mitigate the additional risk associated with a single-stair exit when a second staircase/exit is removed from a structure.

Occupied Floors, Stories, Podiums, Grade
Advisory Group members discussed the nuances and differences between occupied stories, occupied floors, stories above grade, and podium construction as it relates to parameters defined in the authorizing legislation. Advisory Group members agreed that a proposal allowing a single stair exit structure up to six stories would need to consider these factors and may need to impose restrictions in order to provide adequate fire access above a certain height. When considering podium construction, Advisory Group members suggested that building code language clearly define the *lowest occupied floor*. Advisory Group members also noted that the different ways localities calculate grade may need to be considered.

Construction Type
Advisory Group members reviewed the variety of construction material requirements for different multifamily residential structures up to six stories. Some Advisory Group members suggested that any single-stair structures above current limits should be type 1 or 2 construction (noncombustible materials). They stated the reason for this is to support "defend in place" strategies in which a resident may be forced to remain in their unit until emergency help arrives due to a blocked/inaccessible exit. Some Advisory Groups members noted that noncombustible construction types are important to prevent a contents fire from turning into a structural fire, making a "defend in place" strategy more difficult. Other Advisory Group members pointed out the financial costs of noncombustible construction and the challenges this creates for developers of small lots. Some Advisory Group members suggested a higher fire safety rating for only the materials used to construct the stairwell. Other Advisory Group members noted that this does not mitigate risk because occupants do not "defend in place" in the stairwell, but rather they would be forced to stay in occupied rooms, supporting the argument for noncombustible construction throughout. Additionally, it was noted that the building code already requires a two-hour fire rating for stairs four stories and above.

Egress
Advisory Group members discussed expanding egress width beyond current requirements in single-stair structures. Advisory Group members noted that a Canadian study (British Columbia) recommended a single-stair egress width of 5 feet (60 inches). Advisory Group members noted that alternate means of egress may be needed if a structure was built with only one staircase. Other Advisory Group members pointed out that there are no emergency escape rescue openings (EEROs) above three stories, so if a single exit is blocked, the only other egress options would be ariel apparatuses which are challenging and risky for fire departments of varying resources. Some Advisory Group members again emphasized the "defend in place" strategy because a single stair building would be cutting in half the available egress that would otherwise be required for four stories and above.

Occupant Load
Advisory Group members discussed occupant load in the context of number of units. Advisory Group members noted that the current building code establishes occupant load based on square footage calculations. Some Advisory Group members expressed that establishing limits on the number of units allowed should be the primary metric for controlling occupant loads in single-stair construction.

Fire Sprinklers and Fire Alarms
Advisory Group members noted that fire sprinklers and fire alarms are already required in multi-family structures. Some Advisory Group members offered that specific requirements for higher sprinkler densities could be considered to go above and beyond the current building code requirements to mitigate risk in single-stair construction. Advisory Group members also suggested requiring early detection systems in common areas, including the stairwell itself.

Special Inspections
Advisory Group members noted that even though special inspections of fire penetrations are included in the ICC model code, they are not required in Virginia. Advisory Group members indicated that requiring these inspections for single-stair construction could be considered to mitigate risk.

Prop Alarms
Advisory Group members discussed prop alarms as a way to ensure that open doors do not compromise a single stair exit during a fire. Some Advisory Group members remarked that prop alarms are not used to mitigate fire risk from a life safety perspective and that that they are primarily used for security. Advisory Group members pointed out the primary issue with prop alarms in residential buildings is tampering.

Smoke Control
Advisory Group members discussed pressurized smoke systems in the single stairway to make it safer during a fire. Some Advisory Group members noted the lack of research on the prevalence of these systems. Other Advisory Group members highlighted the cost associated with these systems. They said pressurized smoke systems are required in Seattle's single-stair buildings; however, rents are high, and the costs are likely recouped by these higher rents. Advisory Group members also pointed out examples in other jurisdictions of smoke control related to ventilation. Other Advisory Group members noted that ventilation and exhaust systems should only be used for post-fire salvage, and they are not meant to keep a stairwell safe for escaping occupants. They said the reason for this is ventilation systems pull smoke through the stairwell, while pressurization systems keep smoke out of the stairwell entirely.

Capacity and Capability of Fire Department(s), Fire Apparatus, and Water Availability
Advisory Group members again noted that EEROs do not exist at four stories above grade and up. It was noted that occupants at these levels need alternate means of escape if a single staircase is blocked or compromised during a fire. Advisory Group members shared that fire departments may use aerial apparatuses to rescue occupants at these levels, but smaller (often more rural) fire departments may not have the resources to perform these rescues effectively. Advisory Group members highlighted that since the building code is statewide, it should to be written for the minimum resources available. Other Advisory Group members speculated that single-stair buildings would not be built in areas with minimal firefighting resources. It was discussed whether there are any self-regulating mechanisms in the market or the building code itself that would ensure these structures are only built as infill in urban areas (with adequate resources). Advisory Group members pointed out that fire department access in these urban areas is still challenging, even if the fire department has ample resources. Advisory Group members suggested only allowing single-stair construction in areas where fire departments receive certain accreditations. Other Advisory Group members said tying the building code to fire department accreditation may not be beneficial since fire departments can fall in and out of accreditation, while the structures stand for long periods of time.

Firefighter and First Responder Access to the Building
Advisory Group members discussed challenges with firefighter access when only one staircase exists. Topics included access to the perimeter of the building (distance requirements) and alternate forms of access such as fire service elevators. Advisory Group members discussed the challenges with these measures including the costs of fire service elevators.

Benefits
Some Advisory Group members presented on the benefits of single-stair structures including more natural light, more ventilation, space for family size apartments, fitting in small infill lots, and benefits for main streets. Data was presented on the fire safety of single-stair buildings in other jurisdictions and the relative safety of multifamily housing compared to other housing types (single family, older multifamily, etc.). Advisory Group members discussed the relative safety of various housing types and limitations associated with each.

In a second public comment period, a fire service professional highlighted the variety of firefighting resources in different areas of the state and reminded the Advisory Group that the building code is uniform statewide. The fire service professional shared additional thoughts on the challenges of small fire departments, the data presented regarding the relative safety of different housing types, the prevalence of fire sprinklers in multifamily structures, and the ever-changing challenges from new fire hazards (ex. e-bikes and electric vehicles). He further remarked that the problem with single stairwell congestion (firefighters going up, occupants going down) will be very difficult to address even with additional safety features.

Future Considerations
Advisory Group members agreed that structures above three stories with two or more stairs currently have certain fire safety protection measures in place with the understanding that two or more stairs will be present. The Advisory Group acknowledged that there are additional safety challenges and considerations when a staircase is removed from a structure that would otherwise require two staircases under the current building code. The Advisory Group questioned what additional fire safety protection measures need to be present to ensure the safety of residents when a structure (four to six stories) is limited to a single-staircase. Advisory Group members noted that there is currently a spectrum of requirements for structures four to six stories, so it could be possible for a building code proposal to have a spectrum of added requirements for single stair construction (ex. a maximum build for six stories, a minimum build for four stories).

Throughout the meeting, Advisory Group members discussed potential (upgraded) fire safety protections when only one staircase is present in a structure four to six stories. A future single-staircase code proposal could include, but would not be limited to, the following added fire safety protections:

- Requiring construction type 1 or 2 (non-combustible materials) for any single-stair building over three stories
- Closer exterior access to building for fire departments
- Capability of fire department (accreditation)
- Wider egress width. Advisory Group discussed a 60-inch requirement

- Limiting the number of units per floor or net floor area to control occupant load
- Limiting and clearly defining occupied floors
- Pressurizing exit stair enclosure to prevent smoke from entering
- Mechanical smoke ventilation system
- Higher sprinkler density above and beyond current requirements
- Early smoke detection in common areas (stairwell itself)
- Special inspections for penetrations of rated assemblies

Meeting Summary
Single-staircase Advisory Group
November 6, 2024
12:00 PM
Twin Hickory Area Library
5001 Twin Hickory Road, Glen Allen, VA

Advisory Group Member Present:
William Abrahamson, American Institute of Architects Virginia
Hampton Barclay, Private Developer
Eric Cavallo, Private Contractor
Ron Clements, Virginia Building and Code Officials Association
Rick Hinson, American Council of Engineering Companies of Virginia
Alex Horowitz, Pew Charitable Trusts
Billy Hux, State Fire Marshal
Jason Laws, Virginia Building and Code Officials Association
Andrew Milliken, Virginia Fire Services Board
Lyle Solla-Yates, Charlottesville Planning Commission
Dan Willham, Virginia Building and Code Officials Association

DHCD staff attending for all or part of the meeting:
Jeff Brown, State Building Codes Office Director
Andrew Malloy, Policy Analyst
Florin Moldovan, Code and Regulation Specialist
Chase Sawyer, Policy and Legislative Services Manager

Key Takeaways

- The Advisory Group made technical corrections to the draft report to improve its accuracy and limit potential misunderstandings.
- The Advisory Group made additions to the report to provide future workgroups more research and information on this topic.
- The Advisory Group agreed on the contents of the report and the recommendations included within it.

Summary

Department of Housing and Community Development (DHCD) staff opened the floor for public comments at the beginning of the third meeting of the Single-staircase Advisory Group (Advisory Group). DHCD staff shared the draft Advisory Group report with the public prior to the meeting, allowing them the opportunity to comment on its contents.

Two fire service professionals made public comments. The first fire service professional listed the fire service organizations that oppose single-staircase proposals and the concerns they have with escape and rescue operations in single-stair structures. He commended the current code development process in Virginia and emphasized that Virginia has a consensus-based approach. The fire service professional further noted the lack of consensus among stakeholders and urged attendees to hear the concerns of fire safety professionals. He highlighted that current limits on single-stair construction are based on decades of research and investigations of fires in multifamily buildings. The second fire service professional supported the intentions behind this proposal to help address housing affordability. She shared her concerns that more people are experiencing homelessness because of unaffordable housing, especially in northern Virginia. However, she shared concerns that single-stair construction would put occupants at risk. She shared her experience as a first responder needing to block/shut down a staircase in order to transport a patient. She also shared concerns that victims of domestic violence would be limited in their escape options if only one staircase/exit were available.

After the public comments, DHCD staff provided a brief overview of the draft report. DHCD staff invited Advisory Group members to share feedback, comments, edits and additions to the report.

During the discussion, the following edits were made to the draft report:

i. In the background section, Advisory Group members clarified that a model single-staircase proposal was not *developed* by the Advisory Group. Even though different model proposals were discussed in general terms, it would not be accurate to say that the Advisory Group disagreed on specific elements of a proposal.

ii. In the history section, updates were made to reflect the recent efforts of the ICC at the 2024 International Code Council's Committee Action Hearings in Long Beach, CA.

iii. In the section on fire safety considerations, the description and definition of Emergency Escape and Rescue Openings (EEROs) was corrected.

iv. In the list of potential (upgraded) fire safety protections, "ISO class 1 rating" was added to describe the capability of fire departments. This was added to reflect the official industry designation.

v. In the list of potential (upgraded) fire safety protections, Advisory Group members added clarification that future workgroups should work to define occupied floors, roofs, stories, podiums, and grades. As discussed in prior Advisory Group meetings, there are several nuances and differences between occupied stories, occupied floors, occupied roofs, stories above grade, and podium construction as it relates to the parameters defined in the authorizing legislation.

vi. Regarding the list of potential fire safety protections, Advisory Group members said that a cost/benefit analysis should be performed on these requirements. Advisory Group members shared concerns that some of these potential requirements would be overly burdensome for builders and would make single-staircase structures too costly. Advisory Group members also shared that some items on the list may have negligible fire safety benefits that would not outweigh the costs they would impose. Advisory Group members clarified that the list of added fire safety protections is not exhaustive, nor should it be interpreted that all of these protections need to be added in order to reach consensus on this issue. Additionally, the fire safety protections may not all be necessary to mitigate safety risks. DHCD staff also noted that the list of upgraded protections is not presented in any particular order, level of importance, or effectiveness. The list serves as a starting point for future workgroups to consider.

vii. The Advisory Group discussed the specific elements of ICC code change proposal E24-24 as modified by AMC2 (Shapiro MC-1). This proposal as modified would allow single-staircase (exit) buildings up to four stories with additional requirements including limiting net floor area, requiring sprinklers compliant with combustible stairways regardless of construction type, prohibiting electrical receptacles in the stairway, certain requirements for fire alarms and smoke detection systems, and certain requirements for the openings to the stairway. The Advisory Group added to the report that the provisions of floor modification E24-MC1 may provide a beneficial framework for a future single staircase code change proposal.

viii. Advisory Group members suggested additions to the benefits sections to more fully summarize the positions in the attached research articles included in the appendix of the report. Advisory Group members shared benefits of single-stair construction including the flexibility to add more types of multifamily housing, more natural light and ventilation, and adding to the historical appeal of downtown areas.

ix. The Advisory Group made one edit to the recommendations. Advisory Group members specifically named the ICC code change proposal E24-24 as modified as a proposal that a special workgroup in the 2024 building code update cycle should discuss and consider.

After no other edits or additions were proposed by Advisory Group members, DHCD staff again opened the floor for public comments. No additional public comments were made.

Next Steps

The Advisory Group approved of the report’s contents following the incorporation of the revisions discussed and agreed to during the meeting. DHCD staff discussed a deadline for accepting additional statements and research items to be included in the report appendix.

B3005.4-24

VCC: 3005.4; IBC: 3005.4

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2021 Virginia Construction Code

Delete without substitution:

~~**3005.4 Machine and control rooms, control spaces, and machinery spaces.** Elevator machine rooms, rooms and spaces housing elevator controllers, and machinery spaces outside of, but attached to, a hoistway that have openings into the hoistway shall be enclosed with fire barriers constructed in accordance with Section 707 or horizontal assemblies constructed in accordance with Section 711 , or both. The fire-resistance rating shall not be less than the required rating of the hoistway enclosure. Openings in the fire barriers shall be protected with assemblies having a fire protection rating not less than that required for the hoistway enclosure doors.~~

~~**Exceptions:**~~

1. ~~For other than fire service access elevators and occupant evacuation elevators, where elevator machine rooms, rooms and spaces housing elevator controllers, and machinery spaces do not abut and do not have openings to the hoistway enclosure they serve, the fire barrier constructed in accordance with Section 707 or horizontal assemblies constructed in accordance with Section 711 , or both, shall be permitted to be reduced to a 1-hour fire-resistance rating.~~
2. ~~For other than fire service access elevators and occupant evacuation elevators, in *buildings* four stories or less above grade plane when elevator machine rooms, rooms and spaces housing elevator controllers, and machinery spaces do not abut and have no openings to the hoistway enclosure they serve, the elevator machine rooms, rooms and spaces housing elevator controllers, and machinery spaces are not required to be fire-resistance rated.~~

2024 International Building Code

3005.4 Machine rooms, control rooms, machinery spaces, and control spaces. The following rooms and spaces shall be enclosed with *fire barriers* constructed in accordance with Section 707 or *horizontal assemblies* constructed in accordance with Section 711, or both:

1. Machine rooms.
2. Control rooms.
3. Control spaces.
4. Machinery spaces outside of the hoistway enclosure.

The *fire-resistance rating* shall be not less than the required rating of the hoistway enclosure served by the machinery. Openings in the *fire barriers* shall be protected with assemblies having a *fire protection rating* not less than that required for the hoistway enclosure doors.

Exceptions:

1. For other than fire service access elevators and occupant evacuation elevators, where machine rooms, machinery spaces, control rooms and control spaces do not abut and do not have openings to the hoistway enclosure they serve, the *fire barriers* constructed in accordance with Section 707 or *horizontal assemblies* constructed in accordance with Section 711, or both, shall be permitted to be reduced to a 1-hour *fire-resistance rating*.
2. For other than fire service access elevators and occupant evacuation elevators, in *buildings* four *stories* or less above *grade plane* where machine room, machinery spaces, control rooms and control spaces do not abut and do not have openings to the hoistway enclosure they serve, the machine room, machinery spaces, control rooms and control spaces are not required to be fire-resistance rated.

Reason Statement: This code change is to remove the state amendment to VCC 3005.4 and default back to the 2024 IBC Section 3005.4 text without any state amendment. The current Virginia amendment to VCC Section 3005.4 is broken. The body of the Section is specific to fire rating requirements for machine/equipment rooms and spaces that are attached to the elevator shaft. The exceptions are for rooms and spaces that do not abut the shaft, so the exceptions will never be valid and the VCC is silent on how to treat machine rooms and spaces that do not abut the shaft. The 2024 IBC version of 3005.4 does not have this problem so the simple fix is to remove the state amendment and use the 2024 IBC text without state amendment.

Cost Impact: The code change proposal will not increase or decrease the cost

. This code change is fixing a broken Virginia amendment.

B3102.1-24

IBC: 3102.1, 3103.1, 3103.1.3, 3103.2

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2024 International Building Code

Revise as follows:

3102.1 General. The provisions of Sections 3102.1 through 3102.8 shall apply to *air-supported*, *air-inflated*, *membrane-covered cable*, *membrane-covered frame* and *tensile membrane structures*, collectively known as *membrane structures*~~, erected for a period of 180 days or longer. Those erected for a shorter period of time shall comply with the *International Fire Code*~~ . Membrane *structures* covering water storage *facilities*, water clarifiers, water treatment plants, sewage treatment plants, *greenhouses* and similar *facilities* not used for human occupancy are required to meet only the requirements of Sections 3102.3.1 and 3102.7. Membrane *structures* erected on a *building*, balcony, deck or other *structure* for any period of time shall comply with this section.

3103.1 General. The provisions of Sections 3103.1 through 3103.8 shall apply to *structures* erected for a period of less than 180 days. ~~Temporary *special event structures*, *tents*, umbrella *structures* and other membrane *structures* erected for a period of less than 180 days shall also comply with the *International Fire Code* .~~ *Temporary structures* erected for a longer period of time and *public-occupancy temporary structures* shall comply with applicable sections of this code.

Exceptions:

1. *Public-occupancy temporary structures* complying with Section 3103.1.1 shall be permitted to remain in service for 180 days or more but not more than 1 year where *approved* by the *building official*.
2. *Public-occupancy temporary structures* within the confines of an *existing structure* are not required to comply with Section 3103.6.

Delete without substitution:

~~**3103.1.3 Permit required.** *Temporary structures* that cover an area greater than 120 square feet (11.16 m^2), including connecting areas or spaces with a common *means of egress* or entrance that are used or intended to be used for the gathering together of 10 or more *persons*, shall not be erected, operated or maintained for any purpose without obtaining a *permit* from the *building official*.~~

Revise as follows:

3103.2 ~~Construction documents~~Label. ~~A *permit* application and *construction documents* shall be submitted for each installation of a *temporary structure*. The *construction documents*, shall include a site plan indicating the location of the *temporary structure* and information delineating the *means of egress* and the *occupant load loadload*~~ *Membrane structures* or *tents* shall have a permanently affixed label bearing the following information:

1. The identification of size and fabric or material.
2. The names and addresses of the manufacturers of the *tent* or air-supported structure.
3. A statement that the fabric or material meets the requirements of Section 3102.3.1.
4. If treated, the date when a flame-retardant treatment was last applied to the fabric or material, the trade name or kind of chemical used in treatment, name of person or firm treating the fabric or material, and name of testing agency and test standard by which the fabric or material was tested.
5. If untreated, a statement that no treatment was applied when the fabric or material met the requirements of Section 3102.3.1..

Reason Statement:

The tent and membrane structures provisions of the IBC and IFC are set up with the intent that erection of permanent tents and membrane structures is regulated by the IBC and the building official, and erection of temporary tents and membrane structures is regulated by the IFC and the fire official. This is contrary to how the VCC and SFPC are scoped in Virginia. The VCC regulates erection of all tents and membrane structures. The SFPC regulates maintenance and operations of all tents and membrane structures. VCC Chapter 31 is set up based on the IBC/IFC model to send the code user to the IFC for temporary tents and membrane structures. This code structure creates several problems when applied in Virginia. First, as addressed in a companion code change to the SFPC, the construction provisions in the SFPC are invalid and unenforceable by the fire official. Second, the reference in the VCC to the IFC for temporary tents and membrane structures creates numerous conflicts between the IFC and the VCC. Per VCC Section 101.6 #5, when there are conflicts between the VCC and referenced codes or standards the VCC supersedes the referenced code or standard.

Below is a full list of all the IFC code sections applicable to erection of temporary tents and membrane structures and a note as to the validity of the IFC section based on the hierarchy of code established by VCC 101.6 #5. Only IFC Sections 3103.9 thru 3103.9.4, 3104.2 and 3104.3 are applicable, the other sections are the same subject matter as a VCC Section and therefore invalid per VCC 101.6 #5. The proposed revisions to VCC Sections 3102.1 and 3103.1, and relocation of IFC 3104.3 to VCC revised Section 3103 address the subject matter covered in the valid IFC Sections keeping the code user in the VCC. It should not require two code books to simply install a temporary tent. This code change simplifies the code, does not lower levels of safety, reduces regulation, and avoids the need to go to the IFC to hunt for applicable provisions. It also will increase consistency of enforcement as it is doubtful there is currently consistent application considering there are almost 50 IFC code sections that must be evaluated to determine validity.

Explanation of the specific VCC Changes proposed:

3102.1 and 3103.1- Removing the IFC reference from Sections 3102.1 and 3103.1 affects the valid provisions of the IFC, which the analysis provided below demonstrates are sections 3103.9 thru 3103.9.4, 3104.2 and 3104.3. By removing the IFC reference it will allow use of VCC 3102.8 for inflation system requirements instead of IFC Section 3103.9. This solves another problem that the current IBC/IFC organization creates, which is that current VCC 3102.8 is only applicable to permanent structures and IFC 3109.3 and 3109.4 are only applicable to places of public assembly. That leaves any other use, such as an inflatable structure used for a farmers' market or craft fair, without specific requirements for inflation systems. The provisions of IFC 3109.2 for fabric, design and construction are addressed in numerous Sections in VCC chapter 31 with the limitation to permanent structures removed. Additionally, the removal of the IFC references will allow use of VCC 3102.3 thru 3102.3.1 for construction type and membrane fire propagation requirements, instead of IFC Section 3104.2.

3103.1.3- This section is proposed to be deleted because it is invalid per VCC101.6 #1, VCC 108 supersedes.

3103.2- The current Section is invalid as it addresses construction documents, which is superseded by section 109 per VCC101.6 #1. The section is proposed to be revised for relocated IFC Section 3104.3 provisions regarding label requirements on membrane structures.

2024 IFC Sections and why referencing them is not needed or invalid per VCC Section 101.6 #5:

3103.2- Invalid, VCC 108 supersedes.

3103.3- Is applicable in the SFPC and out of scope for VCC.

3103.3.1- Invalid, VCC 3103.1.2 and 411 supersede.

3103.4- Invalid, VCC 3103.1 and 3103.1.1 supersede.

3103.5- Invalid, VCC 109 supersedes.

3103.6 and 3106.1- These provisions are maintenance inspection provisions, which are valid under the SFPC and remain in the SFPC. To the extent they are interpreted to relate to initial erection inspections they are invalid as VCC 113 supersedes.

3103.7- Access and parking are operational issues regulated by the SFPC, not the VCC. Location is invalid as it is regulated by the VCC.

3103.7.1- Is applicable in the SFPC and out of scope for VCC.

3103.7.2 and 3107.3- Location of the tent with respect to other tents and structures is invalid, VCC 3103.3 and 705.5 supersede.

3103..7.4 – This section is just a reference back to the VCC.

3103.7.5- Invalid, VCC 3103.4 supersedes.

3103.7.6- Is applicable in the SFPC and out of scope for VCC.

3103.8 and 3103.8.1- Invalid, VCC 3103.1.2 supersedes.

3103.8.2 thru 3103.8.4- These sections are just referencing back to the VCC.

3103.9 thru 3103.9.4- The proposed revision to VCC Section 3102.1 will allow use of VCC 3102.8 for inflation system requirements instead of IFC Section 3103.9.

3103.10 thru 3103.11.7- Invalid, VCC 3103.4 supersedes.

3103.11.8- Is applicable in the SFPC and out of scope for VCC.

3104.1- The reference to the IBC (VCC) is not needed and the references to 3107 and 3108 are out of scope for VCC. Those provisions remain in the SFPC.

3104.2 The proposed revision to VCC Section 3102.1 will allow use of VCC 3102.3 thru 3102.3.1 for construction type and membrane fire propagation requirements, which will supersede IFC Section 3104.2.

3104.3- This section is proposed to be relocated to VCC revised Section 3103.2 as part of this code change.

3104.4- This section is referencing a non-referenced affidavit to be submitted to the fire official, which is not valid under the VCC.

3105.1- Invalid, since the rest of the section is invalid.

3105.2- Invalid, VCC 108 supersedes.

3105.3- Invalid, VCC 3103.1 and 3103.1.1 supersede.

3105.4- Invalid, VCC 109 supersedes.

3105.5- 3105.5.2- invalid, VCC 113 supersedes

3105.6- Invalid, VCC 3103.4 supersedes.

3105.7- Location of the tent with respect to other tents and structures is invalid, VCC 3103.3 and 705.5 supersede; egress is regulated by VCC 3103.4, apparatus access and egress maintenance are operational issues regulated by the SFPC.

3105.8- Invalid, VCC 3103.1.2 and 906 supersede.

Other sections of IFC Chapter 31 are operations and maintenance provisions that are incorporated into the SFPC.

Cost Impact: The code change proposal will not increase or decrease the cost

This code change is mostly editorial by removing invalid provisions or references to invalid provisions, and relocating other provisions. This code change does not propose new requirements or remove existing requirements that would affect costs.

B3301.1-24

IBC: 3301.1, SECTION 3302, 3302.1, 3302.1.1, 3302.2, 3302.3, 3302.3.1; VEBC: 1201.5

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2024 International Building Code

Revise as follows:

3301.1 Scope. The provisions of this chapter shall govern safety during construction and the protection of adjacent public and private properties. ~~Fire safety during construction shall also comply with the applicable provisions of Chapter 33 of the *International Fire Code*.~~

Delete without substitution:

~~SECTION 3302~~ ~~OWNER'S RESPONSIBILITY FOR FIRE PROTECTION~~

~~**3302.1 Site safety plan.** The *owner* or *owner's* authorized agent shall be responsible for the development, implementation and maintenance of an *approved*, written site safety plan establishing a fire prevention program at the project site applicable throughout all phases of the construction, *repair*, *alteration* or demolition work. The plan shall be submitted and *approved* before a *building permit* is issued. Any changes to the plan shall address the requirements of this chapter and other applicable portions of the *International Fire Code*, the duties of staff and staff training requirements. The plan shall be submitted for approval in accordance with the *International Fire Code*.~~

~~**3302.1.1 Components of site safety plans.** Site safety plans shall include the following, as applicable:~~

1. ~~Name and contact information of site safety director.~~
2. ~~Documentation of the training of the site safety director and fire watch personnel.~~
3. ~~Procedures for reporting emergencies.~~
4. ~~Fire department vehicle access routes.~~
5. ~~Location of fire protection equipment, including portable fire extinguishers, *standpipes*, fire department connections and fire hydrants.~~
6. ~~Smoking and cooking policies, designated areas to be used where *approved*, and signage locations in accordance with the *International Fire Code*.~~
7. ~~Location and safety considerations for temporary heating equipment.~~
8. ~~Hot work permit plan.~~
9. ~~Plans for control of combustible waste material.~~
10. ~~Locations and methods for storage and use of *flammable* and *combustible liquids* and other *hazardous materials*.~~
11. ~~Provisions for site security and, where required, for a fire watch.~~
12. ~~Changes that affect this plan.~~
13. ~~Other site-specific information required by the *International Fire Code*.~~

~~**3302.2 Site safety director.** The *owner* shall designate a *person* to be the site safety director. The site safety director shall be responsible for ensuring compliance with the site safety plan. The site safety director shall have the authority to enforce the provisions of this chapter and other provisions as necessary to secure the intent of this chapter. Where guard service is provided in accordance with~~

~~the *International Fire Code* , the site safety director shall be responsible for the guard service.~~

~~**3302.3 Daily fire safety inspection.** The site safety director shall be responsible for the completion of a daily fire safety inspection at the project site. Each day, all *building* and outdoor areas shall be inspected to ensure compliance with the inspection list in this section. The results of each inspection shall be documented and maintained on-site until a certificate of occupancy has been issued. Documentation shall be immediately available for on-site inspection and review.~~

1. ~~Any contractors entering the site to perform hot work each day have been instructed in the hot work safety requirements in the *International Fire Code* , and hot work is performed only in areas *approved* by the site safety director.~~
2. ~~Temporary heating equipment is maintained away from combustible materials in accordance with the equipment manufacturer's instructions.~~
3. ~~Combustible debris, rubbish and waste material is removed from the *building* in areas where work is not being performed.~~
4. ~~Temporary wiring does not have exposed conductors.~~
5. ~~*Flammable liquids* and other *hazardous materials* are stored in locations that have been approved by the site safety director when not involved in work that is being performed.~~
6. ~~Fire apparatus access roads required by the *International Fire Code* are maintained clear of obstructions that reduce the width of the usable roadway to less than 20 feet (6096 mm).~~
7. ~~Fire hydrants are clearly visible from access roads and are not obstructed.~~
8. ~~The location of fire department connections to standpipe and in-service sprinkler systems are clearly identifiable from the access road and such connections are not obstructed.~~
9. ~~Standpipe systems are in service and continuous to the highest work floor, as specified in Section 3311.~~
10. ~~Portable fire extinguishers are available in locations required by Section 3309 and for roofing operations in accordance with the *International Fire Code.*~~
11. ~~Where a *fire watch* is required, fire watch records complying with the *International Fire Code* are up-to-date.~~

~~**3302.3.1 Violations.** Failure to properly conduct, document and maintain documentation required by this section shall constitute an unlawful act in accordance with Section 114.1 and shall result in the issuance of a notice of violation to the site safety director in accordance with Section 114.2. Upon the third offense, the *building official* is authorized to issue a stop work order in accordance with Section 115, and work shall not resume until satisfactory assurances of future compliance have been presented to and *approved* by the *building official*.~~

2021 Virginia Existing Building Code

Delete without substitution:

~~**1201.5 Fire safety during construction.** Fire safety during construction shall comply with the applicable requirements of the *International Building Code* and the applicable provisions of Chapter 33 of the *International Fire Code*.~~

Reason Statement:

These provisions are operations and maintenance provisions copied out of the IFC and are beyond the scope of building code regulations. Though the IFC and IBC have numerous provisions copied between the codes, the USBC and SFPC have clear lines of delineation between building construction regulations in the USBC and maintenance and operations regulations in the SFPC. These provisions are not regulating the building construction, they are regulating the construction operation, and maintenance of the construction site, which should not be in the USBC and are likely invalid. These provisions will remain in the SFPC. This code change also contributes to regulatory reduction.

Cost Impact: The code change proposal will not increase or decrease the cost

. The requirements proposed for deletion remain in the SFPC so this code change will not significantly decrease the costs for the owner to develop and manage the plan required by the SFPC.

B3301.1-24 Floor Modification

NOTE: the <u>underlined text</u> shows revisions to code change proposal B3301.1-24 (as currently shown in cdpVA), which already incorporates changes to the 2024 IBC and 2021 VEBC.

Proponents: Ron Clements, Chesterfield, representing Building Inspection Department (clementsro@chesterfield.gov)

2024 International Building Code

Revise as follows:

3301.1 Scope. The provisions of this chapter shall govern safety during construction and the protection of adjacent public and private properties.

> <u>**Note:** Fire Safety During Construction plans may be required by the Fire Code Official prior to construction operations in accordance with the Statewide Fire Prevention Code.</u>

2021 Virginia Existing Building Code

1201.1 Scope.

The provisions of this chapter shall govern safety during construction that is under the jurisdiction of this code and the protection of adjacent public and private properties.

> <u>**Note:** Fire Safety During Construction plans may be required by the Fire Code Official prior to construction operations in accordance with the Statewide Fire Prevention Code.</u>

EB504.1.6-24

VEBC: 504.1.6 (New); IRC: E3606.5.3

Proponents: Corian Carney, York County, representing Virginia Chapter IAEI, Eastern Virginia Division IAEI (corian.carney@yorkcounty.gov)

2021 Virginia Existing Building Code

Add new text as follows:

504.1.6 Service Equipment. Where service equipment is replaced supplying all Group R occupancies, and sleeping rooms of Group I-1 and I-2 Occupancies, a surge protective device (SPD) shall be installed in accordance with the following:1.The SPD shall be an integral part of the service equipment, or shall be immediately adjacent thereto.

Exception: The SPD shall not be required to be located at the service equipment if located at each next level distribution equipment downstream toward the load.

2. The SPD shall be a Type 1 or Type 2 SPD.3. SPDs shall have a nominal discharge current rating (In) of not less than 10kA.

2024 International Residential Code

Delete without substitution:

~~**E3606.5.3 Replacement.** Where service equipment is replaced, all of the requirements of this section shall apply. [230.67]~~

Reason Statement: This proposal is intended to relocate the replacement language of the VRC section to the correct location in the Existing Building Code, to avoid confusion between the sections. The Existing Building Code appears to allow replacement of service equipment without the installation of surge protective devices.

Cost Impact: The code change proposal will not increase or decrease the cost
as it is just for clarification.

REC-R402.1.2(1)-24

IRC: TABLE N1102.1.2 (R402.1.2), TABLE N1102.1.3 (R402.1.3)

Proponents: Eric Lacey, representing Responsible Energy Codes Alliance (eric@reca-codes.com)

2024 International Residential Code

Revise as follows:

TABLE N1102.1.2 (R402.1.2) MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS
Portions of table not shown remain unchanged.

CLIMATE ZONE	3	4 EXCEPT MARINE	5 AND MARINE 4
CEILING *U*-FACTOR	~~0.030~~ 0.026	~~0.026~~ 0.024	~~0.026~~ 0.024

For SI: 1 foot = 304.8 mm.

a. Nonfenestration *U*-factors and *F* -factors shall be obtained from measurement, calculation, an approved source or Appendix NF where such appendix is adopted or approved.

b. Mass walls shall be in accordance with Section N1102.2.6. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in Climate Zones 0 and 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. In Warm Humid locations as defined by Figure N1101.7 and Table N1101.7, the *basement wall U*-factor shall not exceed 0.360.

d. A maximum *U*-factor of 0.30 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

1. Above 4,000 feet in elevation above sea level, or
2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

e. *F*-factors for slabs shall correspond to the *R*-values of Table N1102.1.3 and the installation conditions of Section N1102.2.10.1.

TABLE N1102.1.3 (R402.1.3) INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]
Portions of table not shown remain unchanged.

CLIMATE ZONE	3	4 EXCEPT MARINE	5 AND MARINE 4
CEILING *R*-VALUE	~~38~~ 49	~~49~~ 60	~~49~~ 60

For SI: 1 foot = 304.8 mm.NR = Not Required, ci = Continuous Insulation.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. "5ci or 13" means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "10ci or 13" means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "15ci or 19 or 13&5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.

c. Slab insulation shall be installed in accordance with Section N1102.2.10.1.

d. Basement wall insulation shall not be required in Warm Humid locations as defined by Figure N1101.7 and Table N1101.7.

e. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, "13&5" means R-13 cavity insulation plus R-5 continuous insulation.

f. Mass walls shall be in accordance with Section N1102.2.6. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.

g. A maximum *U*-factor of 0.30 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

1. Above 4,000 feet in elevation.

2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

h. "30 or 19+7.5ci or 20ci" means R-30 cavity insulation alone or R-19 cavity insulation with R-7.5 continuous insulation or R-20 continuous insulation alone.

Reason Statement:

This proposal reverses an efficiency rollback incorporated into the 2024 *IECC* by restoring the ceiling insulation R-values to R-60 for Virginia's climate zones (which is the current requirement in the Uniform Construction Code). This requirement was rolled back in the 2024 *IECC* as part of a large compromise among *IECC*-Residential Development Committee Members referred to as the "omnibus." However, significant portions of the omnibus related to electrification and decarbonization were removed from the 2024 *IECC* by the ICC Board of Directors as a result of several appeals, leaving in place several material efficiency rollbacks. These rollbacks would not have been approved in the 2024 *IECC* but for the omnibus compromise, and we recommend that Virginia adopt prescriptive envelope requirements at least as efficient as the 2021 *IECC*. Ceiling insulation is one of the longest-lasting efficiency measures in a building and will provide comfort and energy savings for occupants in all seasons, as well as improved passive survivability in the event of natural disasters and long-term power outages.

Cost Impact: The code change proposal will not increase or decrease the cost

This proposal will maintain Virginia's current ceiling insulation prescriptive baseline, so there will be no increase in construction costs. However, if Virginia reduces ceiling insulation requirements (per the 2024 IECC), this would increase costs for homeowners over the 70-100 year useful life of the building.

REC-R402.1.2(2)-24

VRC: TABLE N1102.1.2 (R402.1.2), TABLE N1102.1.3 (R402.1.3); VCC: 1301.1.1.1

Proponents: Eric Lacey, representing Responsible Energy Codes Alliance (eric@reca-codes.com)

2021 Virginia Residential Code

Revise as follows:

TABLE N1102.1.2 (R402.1.2) MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS
Portions of table not shown remain unchanged.

CLIMATE ZONE	FENESTRATION *U*-FACTOR[f]	SKYLIGHT *U*-FACTOR	GLAZED FENESTRATION SHGC[d, e]	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
3	0.30	0.55	0.25	0.026	0.060 ~~0.079~~	0.098	0.047	0.091c	0.136
4 except Marine	0.30	0.55	0.40	0.024	0.045 ~~0.079~~	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.40	0.024	0.045 ~~0.079~~	0.082	0.033	0.050	0.055

For SI: 1 foot = 304.8 mm.

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. Mass walls shall be in accordance with Section R402.2.5. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in Climate Zones 0 and 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. In Warm Humid locations as defined by Figure R301.1 and Table R301.1, the basement wall *U*-factor shall not exceed 0.360.

d. The SHGC column applies to all glazed fenestration.

Exception: In Climate Zones 0 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

e. There are no SHGC requirements in the Marine Zone.

f. A maximum U-factor of 0.32 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

1. Above 4,000 feet in elevation above sea level, or
2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

TABLE N1102.1.3 (R402.1.3) INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]
Portions of table not shown remain unchanged.

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b, i]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[g]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,g] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,g] WALL *R*-VALUE
3	0.30	0.55	0.25	49	20 or 13&5ci or 0&15ci ~~15 or 13+1~~[g]	8/13	19	5ci or 13[f]	10ci, 2 ft	5ci or 13[f]
4 except Marine	0.30	0.55	0.40	60	30 or 20&5ci or 13&10ci or 0&20ci ~~15 or 13+1~~[g]	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13

5 and Marine 4	0.30	0.55	0.40	60	30 or 20&5ci or 13&10ci or 0&20ci ~~15 or 13+1~~[g]	13/17	30	15ci or 19 or 13&5ci	10ci, 4 ft	15ci or 19 or 13&5ci

For SI: 1 foot = 304.8 mm.

NR = Not Required.

ci = continuous insulation.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

   Exception: In Climate Zones 0 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

c. “5ci or 13” means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. “10ci or 13” means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. “15ci or 19 or 13&5ci” means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.

d. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs. as indicated in the table. The slab-edge insulation for heated slabs shall not be required to extend below the slab.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation shall not be required in Warm Humid locations as defined by Figure N1101.7 and Table N1101.7.

g. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, “13&5” means R-13 cavity insulation plus R-5 continuous insulation.

h. Mass walls shall be in accordance with Section N1102.2.5. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.

i. A maximum *U*-factor of 0.32 shall apply in Climate Zones 3 through 8 to vertical fenestration products installed in buildings located either:

   1. Above 4,000 feet in elevation, or

   2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

2021 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the *International Energy Conservation Code* (IECC). The following changes shall be made to the IECC :

~~14. Change the wood frame wall *R* value categories for Climate Zones 3A, 4A and 5A in Table R402.1.3 to read:~~

		~~Wood Frame Wall *R*-Value~~
		~~15 or 13+1[h]~~

~~15. Change the frame wall *U*-factor categories for Climate Zones 3A, 4A and 5A in Table R402.1.2 to read:~~

		~~Frame Wall *U*-Factor~~
		~~0.079~~

Reason Statement:

This proposal will reduce energy costs for homeowners and improve comfort and passive survivability in new homes by adopting the wall insulation requirements as they appear in the 2021 and 2024 IECC. Virginia is now several cycles behind the model energy code in requirements that apply to wall insulation.

	IECC Wall Insulation R-Value (CZ4)	VA UCC Wall Insulation R-Value (CZ4)
2009	13	13
2012	20 or 13+5	15 or 13+1
2015	20 or 13+5	15 or 13+1
2018	20 or 13+5	15 or 13+1
2021	30 or 20+5 or 13+10 or 0+20	15 or 13+1
2024	30 or 20+5 or 13+10 or 0+20	

Virginia currently allows 75% higher wall U-factors (less stringent) than the 2021/24 IECC. That means Virginia homes allow 75% more heat transfer through the opaque walls than a home built to the 2021 or 2024 IECC. While we understand that initial construction costs are higher with increased insulation requirements, the long-term benefits in lower energy bills and increased comfort for the building owners/occupants are well-documented. Wall insulation is most cost-effectively installed at construction and is likely to remain unchanged over the useful life of the building. The homes constructed today will generate roughly 1200 utility bills (100 years x 12 months), and the amount of wall insulation will directly impact what the homeowner pays every month. It is critical to build new homes to reduce energy use wherever feasible, particularly in the systems and components that will last the longest. Because the IECC provides a wide range of compliance options -- prescriptive, Total UA, simulated performance, Energy Rating Index -- an increase in wall insulation requirements may not require a complete redesign of the proposed home, as long as the home achieves the same overall level of energy savings.

Cost Impact: The code change proposal will increase the cost

In its analysis for the efficiency improvements in the 2021 IECC, the U.S. Department of Energy estimated that the increased construction cost of an additional R-5 continuous insulation would be $0.98/ft2 wall area, or $374.96 for the multifamily prototype/$1,961.96 for the single-family prototype. This improvement was part of a 30-year life-cycle energy cost savings of $2,243 in climate zone 4, with an estimated payback period of 12.4 years. *See* U.S. Department of Energy, *National Cost-Effectiveness of the Residential Provisions of the 2021 IECC* (June 2021).

REC-R402.1.2(3)-24

IRC: TABLE N1102.1.2 (R402.1.2), TABLE N1102.1.3 (R402.1.3)

Proponents: Jason Vandever, North American Insulation Manufacturers Association (NAIMA), representing NAIMA (jvandever@naima.org)

2024 International Residential Code

Revise as follows:

TABLE N1102.1.2 (R402.1.2) MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS
Portions of table not shown remain unchanged.

CLIMATE ZONE	3	4 EXCEPT MARINE	5 AND MARINE 4
ATTIC ROOFLINE U-FACTOR	0.039	0.032	0.032

For SI: 1 foot = 304.8 mm.

a. Nonfenestration *U*-factors and *F*-factors shall be obtained from measurement, calculation, an approved source or Appendix NF where such appendix is adopted or approved.

b. Mass walls shall be in accordance with Section N1102.2.6. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in Climate Zones 0 and 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. In Warm Humid locations as defined by Figure N1101.7 and Table N1101.7, the *basement wall U*-factor shall not exceed 0.360.

d. A maximum *U*-factor of 0.30 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

   1. Above 4,000 feet in elevation above sea level, or
   2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

e. *F*-factors for slabs shall correspond to the *R*-values of Table N1102.1.3 and the installation conditions of Section N1102.2.10.1.

TABLE N1102.1.3 (R402.1.3) INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]
Portions of table not shown remain unchanged.

CLIMATE ZONE	3	4 EXCEPT MARINE	5 AND MARINE 4
ATTIC ROOFLINE R-VALUE	30	38	38

For SI: 1 foot = 304.8 mm.NR = Not Required, ci = Continuous Insulation.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. "5ci or 13" means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "10ci or 13" means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "15ci or 19 or 13&5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.

c. Slab insulation shall be installed in accordance with Section N1102.2.10.1.

d. Basement wall insulation shall not be required in Warm Humid locations as defined by Figure N1101.7 and Table N1101.7.

e. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, “13&5” means R-13 cavity insulation plus R-5 continuous insulation.

f. Mass walls shall be in accordance with Section N1102.2.6. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.

g. A maximum *U*-factor of 0.30 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

1. Above 4,000 feet in elevation.

2. In windborne debris regions where protection of openings is required by Section R301.2.1.2.

h. “30 or 19+7.5ci or 20ci” means R-30 cavity insulation alone or R-19 cavity insulation with R-7.5 continuous insulation or R-20 continuous insulation alone.

Reason Statement: This proposal provides more compliance alternatives for insulating ceilings/roofs, while also maintaining equivalence with the current prescriptive requirements. During the development of the 2024 IECC, new rows in the prescriptive U-factor and R-value tables were added for "insulation entirely above roof deck". We support this change, and we assume that it will be included in the base document update for Virginia’s 2024 IECC adoption. The proposal above adds another row to the prescriptive insulation tables that we believe will promote good construction practices and provide an equivalent level of energy savings. In the 2027 IECC, proposal RE30-24 added new rows for "attic roofline U-factor" and "attic roofline R-value". The U-factors were selected to align with the 2024 IECC addition of "insulation entirely above roof deck" and the appropriate R-values were selected after calculation of typical roof assemblies- to align the thermal resistance with the U-factors. The U-factors and R-values in the RE30-24 proposal were unanimously approved at the subgroup and unanimously approved at the Residential Consensus Committee with a vote of 35-0. Note: The U-factors and R-values proposed above are calculated to be equivalent to an R-49 ceiling insulation requirement, which reflects the reduction in ceiling insulation in the 2024 IECC. If Virginia maintains its current ceiling R-value requirement of R-60, we can re-calculate these values to maintain equivalence.

Cost Impact: The code change proposal will not increase or decrease the cost

This proposal is an option and will neither increase or decrease costs.

Attached Files

- **RE30-24_1751383997.pdf**
  https://va.cdpaccess.com/proposal/1337/1902/files/download/926/

RE30-24

IECC: TABLE R402.1.2, TABLE R402.1.3

Proponents: Aaron Gary, representing Self (aaron.gary@texenergy.org)

2024 International Energy Conservation Code [RE Project]

Revise as follows:

TABLE R402.1.2 MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS

CLIMATE ZONE	0	1	2	3	4 EXCEPT MARINE	5 AND MARINE 4	6	7 AND 8
Vertical fenestration *U*-factor	0.50	0.50	0.40	0.30	0.30	0.28[d]	0.28[d]	0.27[d]
Skylight *U*-factor	0.60	0.60	0.60	0.53	0.53	0.50	0.50	0.50
Glazed vertical fenestration SHGC	0.25	0.25	0.25	0.25	0.40	NR	NR	NR
Skylight SHGC	0.28	0.28	0.28	0.28	0.40	NR	NR	NR
Ceiling *U*-factor	0.035	0.035	0.030	0.030	0.026	0.026	0.026	0.026
Attic Roofline *U*-factor	0.039	0.039	0.039	0.039	0.032	0.032	0.032	0.028
Insulation entirely above roof deck	0.039	0.039	0.039	0.039	0.032	0.032	0.032	0.028
Wood-framed wall *U*-factor	0.084	0.084	0.084	0.060	0.045	0.045	0.045	0.045
Mass wall *U*-factor[b]	0.197	0.197	0.165	0.098	0.098	0.082	0.060	0.057
Floor *U*-factor	0.064	0.064	0.064	0.047	0.047	0.033	0.033	0.028
Basement wall *U*-factor	0.360	0.360	0.360	0.091[c]	0.059	0.050	0.050	0.050
Unheated slab *F*-factor[e]	0.73	0.73	0.73	0.54	0.51	0.51	0.48	0.48
Heated slab *F*-factor[e]	0.74	0.74	0.74	0.66	0.66	0.66	0.66	0.66
Crawl space wall *U*-factor	0.477	0.477	0.477	0.136	0.065	0.055	0.055	0.055

For SI: 1 foot = 304.8 mm.

a. Nonfenestration *U*-factors and *F*-factors shall be obtained from measurement, calculation, an *approved source* , or Appendix RF where such appendix is adopted or *approved* .

b. Mass walls shall be in accordance with Section R402.2.6. Where more than half the insulation is on the interior, the mass wall U-factors shall not exceed 0.17 in Climate Zones 0 and 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. In Warm Humid locations as defined by Figure R301.1 and Table R301.1, the basement wall *U*-factor shall not exceed 0.360.

d. A maximum *U*-factor of 0.30 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

1. Above 4,000 feet in elevation above sea level, or
2. In windborne debris regions where protection of openings is required by Section R301.2.1.2 of the *International Residential Code*.

e. *F*-factors for slabs shall correspond to the *R*-values of Table R402.1.3 and the installation conditions of Section R402.2.10.1.

TABLE R402.1.3 INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	0	1	2	3	4 EXCEPT MARINE	5 AND MARINE 4	6	7 AND 8
Vertical fenestration *U*-factor	0.50	0.50	0.40	0.30	0.30	0.28[g]	0.28[g]	0.27[g]
Skylight *U*-factor	0.60	0.60	0.60	0.53	0.53	0.50	0.50	0.50
Glazed vertical fenestration SHGC	0.25	0.25	0.25	0.25	0.40	NR	NR	NR
Skylight SHGC	0.28	0.28	0.28	0.28	0.40	NR	NR	NR
Ceiling *R*-value	30	30	38	38	49	49	49	49
Insulation entirely above roof deck	25ci	25ci	25ci	25ci	30ci	30ci	30ci	35ci
Attic Roofline R-value	30&0ci	30&0ci	30&0ci	30&0ci	38&0ci	38&0ci	38&0ci	41&0ci
Wood-framed wall *R*-value[e]	13 or 0&10ci	13 or 0&10ci	13 or 0&10ci	20 or 13&5ci or 0&15ci	30 or 20&5ci or 13&10ci or 0&20ci	30 or 20&5ci or 13&10ci or 0&20ci	30 or 20&5ci or 13&10ci or 0&20ci	30 or 20&5ci or 13&10ci or 0&20ci

Mass wall *R*-value[f]	3/4	3/4	4/6	8/13	8/13	13/17	15/20	19/21
Floor *R*-value[h]	13 or 7+5ci or 10ci	13 or 7+5ci or 10ci	13 or 7+5ci or 10ci	19 or 13+5ci or 15ci	19 or 13+5ci or 15ci	30 or 19+7.5ci or 20ci	30 or 19+7.5ci or 20ci	38 or 19+10ci or 25ci
Basement wall *R*-value[b, e]	0	0	0	5ci or 13[d]	10ci or 13	15ci or 19 or 13&5ci	15ci or 19 or 13&5ci	15ci or 19 or 13&5ci
Unheated slab *R*-value & depth[c]	0	0	0	10ci, 2 ft	10ci, 3 ft	10ci, 3 ft	10ci, 4 ft	10ci, 4 ft
Heated slab *R*-value & depth[c]	R-5ci edge and R-5 full slab	R-5ci edge and R-5 full slab	R-5ci edge and R-5 full slab	R-10ci, 2 ft and R-5 full slab	R-10ci, 3 ft and R-5 full slab	R-10ci, 3 ft and R-5 full slab	R-10ci, 4 ft and R-5 full slab	R-10ci, 4 ft and R-5 full slab
Crawl space wall *R*-value[b, e]	0	0	0	5ci or 13[d]	10ci or 13	15ci or 19 or 13&5ci	15ci or 19 or 13&5ci	15ci or 19 or 13&5ci

For SI: 1 foot = 304.8 mm.

NR = Not Required, ci = Continuous Insulation.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. “5ci or 13” means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "10ci or 13" means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "15ci or 19 or 13&5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.

c. Slab insulation shall be installed in accordance with Section R402.2.10.1.

d. Basement wall insulation is not required in Warm Humid locations as defined by Figure R301.1 and Table R301.1.

e. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, “13&5” means R-13 cavity insulation plus R-5 continuous insulation.

f. Mass walls shall be in accordance with Section R402.2.6. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.

g. A maximum *U*-factor of 0.30 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:
   1. Above 4,000 feet in elevation.
   2. In windborne debris regions where protection of openings is required by Section R301.2.1.2 of the *International Residential Code*.

h. "30 or 19+7.5ci or 20ci" means R-30 cavity insulation alone or R-19 cavity insulation with R-7.5 continuous insulation or R-20 continuous insulation alone.

Reason: Providing insulation below the roof deck in a sealed attic meets the same intent and savings as insulation above the roof deck but at lower cost.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
Providing an additional option on how to insulate and attic provides more flexibility allowing construction professionals to select the most cost effective solution, without degrading the energy performance of the home.

Cost Impact (Detailed): The change proposal is editorial in nature or a clarification and has no cost impact on the cost of construction

Justification: Provides more flexibility without degrading energy performance.

REC-R402.4.1.2-24

VRC: N1102.4.1.2, N1102.4.1.3; VCC: 1301.1.1.1

Proponents: Eric Lacey, representing Responsible Energy Codes Alliance (eric@reca-codes.com)

2021 Virginia Residential Code

Delete without substitution:

~~**N1102.4.1.2 (R402.4.1.2) Testing.** The building or *dwelling unit* shall be tested and verified as having an air leakage rate not exceeding 5 air changes per hour. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inches w.g. (50 Pa). A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia registered design professional, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the equipment used to perform the test. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.~~

> ~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of temporary certificate of occupancy in accordance with Section 116.1.1.~~

~~**During testing:**~~

1. ~~Exterior windows and doors and fireplace and stove doors shall be closed, but not sealed beyond the intended weather stripping or other infiltration control measures;~~
2. ~~Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;~~
3. ~~Interior doors, if installed at the time of the test, shall be open;~~
4. ~~Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;~~
5. ~~Heating and cooling systems, if installed at the time of the test, shall be turned off; and~~
6. ~~Supply and return registers, if installed at the time of the test, shall be fully open.~~

~~**Exception:** When testing individual *dwelling units*, an air leakage rate not exceeding 0.30 cubic feet per minute per square foot [0.008 $m^3/(s \times m^2)$] of the *dwelling unit* enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch water gauge (50 Pa), shall be permitted in all climate zones for:~~

1. ~~Attached single- and multiple-family building *dwelling units*.~~
2. ~~Buildings or *dwelling units* that are 1,500 square feet (139.4 m^2) or smaller.~~

~~Mechanical *ventilation* shall be provided in accordance with Section M1505 of this code or Section 403.3.2 of the *International Mechanical Code*, as applicable, or with other *approved* means of *ventilation*.~~

~~**N1102.4.1.3 (R402.4.1.3) Leakage rate.** When complying with Section N1101.2.1 (R401.2.1), the building or *dwelling unit* shall have an air leakage rate not exceeding 5 air changes per hour in Climate Zones 3 through 5, when tested in accordance with Section N1102.4.1.2 (R402.4.1.2).~~

2021 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the *International Energy Conservation Code* (IECC). The following changes shall be made to the IECC :

~~19. Change Section R402.4.1.2 of the IECC to read:~~

~~**R402.4.1.2 Testing.** The *building* or dwelling unit shall be tested and verified as having an air leakage rate not exceeding five air changes per hour. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia *registered design professional*, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the equipment used to perform the test. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.~~

~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1 .~~

~~**During testing:**~~

1. ~~Exterior windows and doors and fireplace and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures.~~
2. ~~Dampers, including exhaust, intake, makeup air, backdraft and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures.~~
3. ~~Interior doors, if installed at the time of the test, shall be open.~~
4. ~~Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed.~~
5. ~~Heating and cooling systems, if installed at the time of the test, shall be turned off.~~
6. ~~Supply and return registers, if installed at the time of the test, shall be fully open.~~

~~20. Change Section R402.4.1.3 of the IECC to read:~~

~~**R402.4.1.3 Leakage rate.** When complying with Section R401.2.1 , the building or dwelling unit shall have an air leakage rate not exceeding 5.0 air changes per hour in Climate Zones 3 through 5, when tested in accordance with Section R402.4.1.2 .~~

Reason Statement:

This proposal would improve the efficiency and durability of residential buildings and help maintain healthier indoor air quality by incorporating the air leakage testing requirements of the 2024 IECC into Virginia's code. Since the 2012 edition, the IECC has required all new residential dwellings in Virginia's climate zones to be tested and to verify a maximum total envelope leakage of 3.0 ACH50. However, Virginia did not adopt a testing requirement until the 2018 edition of the VCC, and set the maximum leakage allowance at 5.0 ACH50. That requirement remained unchanged in the 2021 VCC update, even though the 2021 IECC adopted additional flexibility that allows code users several alternatives for meeting the air tightness requirements. We believe Virginia is ready to catch up with the IECC envelope air leakage requirements. A well-sealed, verified thermal envelope will provide energy savings and promote better indoor air quality over the 70- to 100-year useful life of the home.

This proposal intends to delete the VA-specific amendments in order to incorporate the 2024 IECC air leakage testing requirements as published. This would result in the following changes:

1. All new dwelling units would be required to be air leakage tested, but the maximum allowable leakage for prescriptive compliance would improve from 5.0 ACH50 to 3.0 ACH50 in all Virginia climate zones.

2. The performance path baseline (R405) would be set at 3.0 ACH50, but dwellings could test as high as 5.0 ACH50 as long as efficiency losses are accounted for in other efficiency improvements. This allows considerable flexibility for code users who still find it challenging to achieve 3.0 ACH50, while maintaining the same overall efficiency required by the code.

3. Multifamily dwelling units (of any size) and buildings with 1500 square feet or less of conditioned floor area have the option to be tested to 0.27 cfm/min/ft2 of testing unit enclosure area. This will help address the challenges of achieving low ACH in smaller dwellings.

Cost Impact: The code change proposal will increase the cost

It is possible that some additional time or materials will be required to achieve the lower air leakage number; however, we note that the largest cost is typically the cost of the blower door test itself, which is already required under the VA UCC.

REC-R405.2-24

IRC: N1105.2 (R405.2), TABLE N1105.4.2(1) [R405.4.2(1)]

Proponents: Eric Lacey, representing Responsible Energy Codes Alliance (eric@reca-codes.com)

2024 International Residential Code

Revise as follows:

N1105.2 (R405.2) Simulated building performance compliance. Compliance based on *simulated building performance* requires that a *building* comply with the following:

1. The requirements of the sections indicated within Table N1105.2.
2. The proposed total *building thermal envelope* thermal conductance (TC) shall be less than or equal to the required total *building thermal envelope* TC using the prescriptive *U-factors* and *F-factors* from Table N1102.1.2 multiplied by 1.08 in *Climate Zones* 0, 1 and 2, and 1.15 in Climates Zones 3 through 8, in accordance with Equation 11-6 and Section N1102.1.5. The area-weighted maximum *fenestrationSHGC* permitted in Climate Zones 0 through 3 shall be 0.30.

$$\text{For Climate Zones 0–2: } TC_{Proposed\ design} \leq 1.08 \times TC_{Prescriptive\ reference\ design}$$
$$\text{For Climate Zones 3–8: } TC_{Proposed\ design} \leq 1.15 \times TC_{Prescriptive\ reference\ design}$$

Equation 11-6

3. For each *dwelling unit*~~with one or more fuel-burning *appliances* for space heating, water heating, or both, the annual *energy cost* of the *dwelling unit* shall be less than or equal to 80 percent of the annual *energy cost* of the *standard reference design*. For all other *dwelling units*,~~ the annual *energy cost* of the *proposed design* shall be less than or equal to 89 ~~85~~percent of the annual *energy cost* of the *standard reference design*. For each *dwelling unit* with greater than 5,000 square feet (465 m^2) of *living space* located above *grade plane*, the annual *energy cost* of the *dwelling unit* shall be reduced by an additional 5 percent of annual *energy cost* of the *standard reference design*. Energy prices shall be taken from an *approved source*, such as the US Energy Information Administration's State Energy Data System prices and expenditures reports. Code officials shall be permitted to require time-of-use pricing in *energy cost* calculations.

   Exceptions:

   1. The energy use based on source energy expressed in *Btu* or *Btu* per square foot of *conditioned floor area* shall be permitted to be substituted for the *energy cost*. The source energy multiplier for electricity shall be 2.51 . The source energy multipliers shall be 1.09 for natural gas, 1.15 for propane, 1.19 for *fuel oil*, and 1.30 for imported liquified natural gas.
   2. The energy use based on site energy expressed in *Btu* or *Btu* per square foot of *conditioned floor area* shall be permitted to be substituted for the *energy cost.*

TABLE N1105.4.2(1) [R405.4.2(1)] SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS
Portions of table not shown remain unchanged.

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Heating systems[d, e, j, k]	Fuel Type/Capacity: same as proposed design.	As proposed.
	Product class: same as proposed design.	As proposed.
	Efficiencies: For other than electric heating without a heat pump: same as proposed design. Where the proposed design utilizes electric heating without a heat pump, the standard reference design shall be an air source heat pump meeting the requirements of Section C403 of the *IECC* – Commercial Provisions.	As proposed.
	~~Heat pump: complying with 10 CFR §430.32~~	~~As proposed~~
	~~Fuel gas and liquid fuel furnaces: complying with 10 CFR §430.32~~	~~As proposed.~~
	~~Fuel gas and liquid fuel boilers: complying with 10 CFR §430.32~~	~~As proposed.~~

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Cooling systems[d, f, k]	Fuel Type: electric Capacity: same as proposed design	As proposed.
	Efficiencies: ~~complying with 10 CFR §430.32~~ Same as proposed design.	As proposed.
Service water heating[d, g, k]	Use, in units of gal/day = 25.5 + (8.5 × N_{br}) where: N_{br} = number of bedrooms.	Use, in units of gal/day = 25.5 + (8.5 × N_{br}) × (1 – $HWDS$) where: N_{br} = number of bedrooms. $HWDS$ = factor for the compactness of the hot water distribution system. Compactness ratio[i] factor: 1 story / 2 or more stories / HWDS > 60% / > 30% / 0 > 30% to ≤ 60% / > 15% to ≤ 30% / 0.05 > 15% to ≤ 30% / > 7.5% to ≤ 15% / 0.10 < 15% / < 7.5% / 0.15
	Fuel type: same as proposed design	As proposed.
	Rated storage volume: same as proposed design	As proposed.
	Draw pattern: same as proposed design	As proposed.
	Efficiencies: ~~Uniform Energy Factor complying with 10 CFR §430.32~~ Same as proposed design.	As proposed.
	Tank temperature: 120°F (48.9°C)	Same as standard reference design.
Thermal distribution systems	Duct insulation: in accordance with Section N1103.3.3.	Duct insulation: as proposed.[m]
	Duct location: Same as proposed design.	Duct location: as proposed.[l]
	~~Foundation type~~ / ~~Slab on grade~~ / ~~Unconditioned crawl space~~ / ~~Basement or conditioned crawl space~~	—
	~~Duct location (supply and return)~~ / ~~One-story building: 100% in unconditioned attic All other: 75% in unconditioned attic and 25% inside conditioned space~~ / ~~One-story building: 100% in unconditioned crawl space All other: 75% in unconditioned crawl space and 25% inside conditioned space~~ / ~~75% inside conditioned space 25% unconditioned attic~~	Duct system leakage to outside: The measured total duct system leakage rate shall be entered into the software as the duct system leakage to outside rate. **Exceptions:** 1. Where duct system leakage to outside is tested in accordance ANSI/RESNET/ICC 380 or ASTM E1554, the measured value shall be permitted to be entered. 2. Where total duct system leakage is measured without space conditioning equipment installed, the simulation value shall be 4 cfm per 100ft^2 of conditioned floor area.
	Duct system leakage to outside: for duct systems serving > 1,000 ft^2 of conditioned floor area, the duct leakage to outside rate shall be 4 cfm per 100 ft^2 of conditioned floor area. For duct systems serving ≤ 1,000 ft^2 of conditioned floor area, the duct leakage to outside rate shall be 40 cfm.	
	Distribution System Efficiency (DSE): for hydronic systems and ductless systems a thermal distribution system efficiency (DSE) of 0.88 shall be applied to both the heating and cooling system efficiencies.	Distribution System Efficiency (DSE): for hydronic systems and ductless systems, DSE shall be as specified in Table N1105.4.2(2).

For SI: 1 square foot = 0.93 m^2, 1 British thermal unit = 1055 J, 1 pound per square foot = 4.88 kg/m^2, 1 gallon (US) = 3.785 L, °C = (°F – 32)/1.8, 1 degree = 0.79 rad, 1 cubic foot per minute = 28.317 L/min.

a. Hourly calculations as specified in the ASHRAE Handbook of Fundamentals , or the equivalent, shall be used to determine the energy loads resulting from infiltration.

b. The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with Equation 43 of 2001 ASHRAE Handbook of Fundamentals , page 26.24 and the “Whole-house Ventilation” provisions of 2001 ASHRAE Handbook of Fundamentals , page 26.19 for intermittent mechanical ventilation.

c. Thermal storage element shall mean a component that is not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase-change containers. A thermal storage element shall be in the same room as fenestration that faces within 15 degrees (0.26 rad) of true south, or shall be connected to such a room with pipes or ducts that allow the element to be actively charged.

d. For a proposed design with multiple heating, cooling or water heating systems using different fuel types, the applicable standard reference design system capacities and fuel types shall be weighted in accordance with their respective loads as calculated by accepted engineering practice for each equipment and fuel type present.

e. For a proposed design without a proposed heating system, a heating system having the prevailing federal minimum efficiency shall be assumed for both the standard reference design and proposed design.

f. For a proposed design without a proposed cooling system, an electric air conditioner having the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.

g. For a proposed design with a nonstorage-type water heater,For a proposed design without a proposed water heater, the following assumptions shall be made for both the proposed design and standard reference design. For a proposed design with a heat pump water heater, the following assumptions shall be made for the standard reference design, except the fuel type shall be electric:

Fuel Type: Same as the predominant heating fuel type

Rated Storage Volume: 40 gallons

Draw Pattern: Medium

Efficiency: Uniform Energy Factor complying with 10 CFR §430.32

h. For residences with conditioned basements, R-2 and R-4 residences, and for townhouses, the following formula shall be used to determine glazing area:

$AF = A_S \times FA \times F$

where:

AF = Total glazing area.

A_S = Standard reference design total glazing area.

FA = (Above-grade thermal boundary gross wall area)/(above-grade boundary wall area + 0.5 × below-grade boundary wall area).

F = (above-grade thermal boundary wall area)/(above-grade thermal boundary wall area + common wall area) or 0.56, whichever is greater.

and where:

- Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions.
- Above-grade thermal boundary wall is any thermal boundary wall component not in contact with soil.
- Below-grade boundary wall is any thermal boundary wall in soil contact.
- Common wall area is the area of walls shared with an adjoining dwelling unit.

i. The factor for the compactness of the hot water distribution system is the ratio of the area of the rectangle that bounds the source of hot water and the fixtures that it serves (the “hot water rectangle”) divided by the floor area of the dwelling.

1. Sources of hot water include water heaters, or in multiple-family buildings with central water heating systems, circulation loops or electric heat traced pipes.
2. The hot water rectangle shall include the source of hot water and the points of termination of all hot water fixture supply piping.
3. The hot water rectangle shall be shown on the floor plans and the area shall be computed to the nearest square foot.
4. Where there is more than one water heater and each water heater serves different plumbing fixtures and appliances, it is permissible to establish a separate hot water rectangle for each hot water distribution system and add the area of these rectangles together to determine the compactness ratio.
5. The basement or attic shall be counted as a story when it contains the water heater.
6. Compliance shall be demonstrated by providing a drawing on the plans that shows the hot water distribution system rectangle(s), comparing the area of the rectangle(s) to the area of the dwelling and identifying the appropriate compactness ratio and *HWDS* factor.

j. For a proposed design with electric resistance heating, a split system heat pump complying with 10 CFR §430.32 (2021) shall be assumed modeled in the standard reference design.

k. For heating systems, cooling systems, or water heating systems not included in this table, the standard reference design shall be the same as proposed design.

l. Only sections of ductwork that are installed in accordance with Section N1103.3.4, Items 1 and 2 are assumed to be located completely inside conditioned space. All other sections of ductwork are not assumed to be located completely inside conditioned space.

m. Sections of ductwork installed in accordance with Section N1103.3.5.1 are assumed to have an effective duct insulation *R*-value of R-25.

Reason Statement:

The proposed changes above will reverse the largest efficiency rollbacks incorporated into the 2024 *IECC* and maintain Virginia's current performance path approach to efficiency trade-offs for heating, cooling, and water heating equipment. It will also eliminate an unnecessary new credit for duct location. The proposal will also incorporate a single efficiency improvement to buildings with all equipment types based on the U.S. Department of Energy's Determination that the 2024 IECC reduced annual energy costs by roughly 6.6% as compared to the 2021 IECC. We believe the combination of these changes will allow Virginia code users to continue to use the performance path essentially as they do today, avoiding the controversies that have accompanied the 2024 IECC revisions to this section.

All of these new trade-off credits were included in the 2024 *IECC* as part of a large compromise among *IECC*-R Development Committee Members referred to as the “omnibus.” However, significant portions of the omnibus related to electrification and decarbonization were removed from the 2024 *IECC* by the ICC Board of Directors as a result of several appeals, leaving in place several material efficiency rollbacks. These rollbacks would not have been approved in the 2024 *IECC* but for the omnibus compromise, and we recommend that Virginia eliminate these trade-off credits to be consistent with the 2021 *IECC* and the current VA Construction Code approach to equipment efficiency in the performance path.

Equipment trade-offs were correctly eliminated in the 2009 version of the *IECC* (and in Virginia's adoption of the 2009 IRC/IECC) and were consistently rejected in every *IECC* and Virginia code update cycle until the ICC Residential Committee-developed 2024 *IECC*. Nearly every state that adopts the *IECC* has eliminated these trade-offs as well. Equipment trade-offs reduce building efficiency because commonly installed cooling, heating, and water heating equipment typically exceeds the federal minimum efficiencies, but states are unable to set more reasonable efficiency requirements (or more reasonable assumptions in the standard reference design baseline) because of federal preemption. **The result is an unwarranted trade-off credit that allows buildings to be constructed 11-22% less efficient overall than if the trade-offs were not allowed**. *See* ICF International, *Review and Analysis of Equipment Trade-offs in Residential Energy Codes,* at ii (Sep. 23, 2013).

Although proponents of equipment trade-offs argue that they are “energy neutral,” the reality is that they are a short-term trade-off that will have long-term negative impacts on homeowners –who are often unaware that such trade-offs are taking place. For example, if a trade-off is permitted for water heater efficiency, an instantaneous natural gas water heater would allow the builder to reduce the efficiency of the rest of the home by an average of 9%. The remaining home will be 9% less efficient for its entire useful lifetime. As the water heater is replaced every 10-15 years, the envelope of that home will continue to underperform by 9%. By contrast, under the current Virginia Construction Code (and the 2021 *IECC*), no trade-off credit is awarded for the instantaneous water heater, which means the rest of the home will be built to meet the code. As the water heater is swapped out in future years, a home built to the current Virginia UCC-compliant home will outperform a home built using a water heater performance trade-off allowed by 9%.

Regarding duct location, the current Virginia Uniform Construction Code does not award performance path trade-off credit for ducts located inside conditioned space. In both the prescriptive path and the performance path, builders are neither penalized nor credited for the location of duct systems. Although it is generally good building practice to locate all ducts and air handlers inside conditioned space, many builders in Virginia already do this.

The 2024 *IECC* already provides another performance-based alternative that provides credit for equipment efficiency and duct location (the Energy Rating Index), as well as multiple credits for equipment and duct location in Table R408.2. Both of these compliance paths do not carry such a high risk of free ridership (and reduced overall efficiency) as the proposed performance path credits. The simulated performance path lacks several of the built-in protections of the ERI path, and thus cannot guarantee an equivalent level of performance. We strongly recommend eliminating these loopholes from the performance path and implementing provisions consistent with the Virginia Construction Code and the 2021 *IECC*.

Finally, this proposal replaces the two multipliers in Section N1105.2(3)/R405.2(3) with a single multiplier. Although we do not oppose setting a different multiplier based on whether a home uses fossil fuel-fired or electric appliances, for a starting place we recommend setting a multiplier that is consistent with the U.S. Department of Energy's Determination on energy cost savings associated with the prescriptive path of the 2024 IECC, and one that properly reflects the impact of equipment trade-offs (if any). In December of 2024, U.S. DOE found that homes built to the 2024 IECC prescriptive path will have 6.6% lower annual energy costs than homes built to the 2021 IECC, on average. *See* U.S. Department of Energy, *Notification of Determination*, 89 Fed. Reg. 106458 (Dec. 30, 2024). The current Virginia Construction Code already requires that the proposed home in Section R405 not exceed 95% of the annual energy costs of the standard reference design home. A 6.6% reduction in energy costs is roughly 89%, and that number is proposed above as a single multiplier. We note, however, that if efficiency trade-offs are allowed for heating, cooling, water heating equipment, or for duct location, there would need to be additional changes to the multiplier, and the result would likely be lower than the 80/85% in the published 2024 IECC. However, for purposes of this proposal, assuming the equipment trade-offs and duct location credit are deleted, we view 89% as a reasonable starting place that would maintain consistency across compliance paths.

Cost Impact: The code change proposal will increase the cost

This proposal improves the overall efficiency of the performance path by roughly 6.6%, which may increase costs depending on decisions made by code users. However, these changes, taken as a single package, would maintain consistency with improvements made in the prescriptive path.

REC-R408.2.9-24

IRC: N1108.2.9 (R408.2.9)

Proponents: Eric Lacey, representing Responsible Energy Codes Alliance (eric@reca-codes.com)

2024 International Residential Code

Delete without substitution:

~~**N1108.2.9 (R408.2.9) Opaque walls.** For *buildings* in Climate Zones 4 and 5, the maximum *U-factor* of 0.060 shall be permitted to be used for wood-framed walls for compliance with Table N1102.1.2 where complying with one or more of the following:~~

1. ~~Primary space heating is provided by a *heat pump* that meets one of the efficiencies in Section N1108.2.2.~~
2. ~~All installed *water heaters* are *heat pumps* that meet one of the efficiencies in Section N1108.2.3.~~
3. ~~In addition to the number of credits required by Section N1108.2, three additional credits are achieved.~~
4. ~~*Renewable energy resources* are installed to meet the requirements of Section N1108.2.7.~~

Reason Statement:

New Section R408.2.9 is an efficiency loophole incorporated into the 2024 *IECC* with potential long-term negative impacts. It allows a reduction in wall insulation where one of four conditions is met. There are several problems with this section:

1. None of the specific measures will provide efficiency for as long as the wall insulation being traded off. Measures 1 and 2 have significantly shorter useful lifetimes than wall insulation; measure 4 creates an efficiency trade-off for renewable energy, which is not allowed in either the prescriptive or performance paths of the *IECC*; and measure 3 allows a code user to select 3 more credits from Table R408.2, effectively creating a prescriptive envelope trade-off for 40+ measures that may or may not match the longevity or efficiency of wall insulation. No analysis was provided to justify this trade-off or to quantify whether these measures could save a comparable amount of energy as well-insulated walls.

2. Some advocates have been urging states to allow double-counting of these measures, effectively reducing envelope efficiency without any improvements elsewhere in the building. The charging language does not clarify whether measures 1, 2, and 4 are *in addition to* measures already used to comply with Section R408.2, or whether a code user may simply double-count these measures and reduce envelope efficiency. Neither the proponent's reason statement for this measure (REPI-33-21) nor any of the debate in the 2024 IECC development cycle addressed the possibility of double-counting, and it would seem to contradict language in measure 3 (which requires 3 credits "in addition to the number of credits required by Section R408.2"). Yet advocates at the state and national level have argued that code users should receive credit for these measures both to comply with Section R408.2 and to receive the benefits of an insulation reduction under R408.2.9.

This entire section is problematic, and will only to lead to reduced efficiency. The only reason it is included in the 2024 IECC is because it was part of a deal among IECC Residential Consensus Committee members where sustainability measures and efficiency rollbacks that failed to achieve the required number of votes were grouped into a large "omnibus" package. In response to several appeals, the ICC Board of Directors later reversed the portions of the omnibus related to sustainability, but left in place the efficiency rollbacks, making the 2024 IECC less stringent than the 2021 IECC in several places. Other states considering the 2024 IECC have either deleted this controversial section or are in the process of debating it. We strongly recommend deleting the entire section and maintaining the stringency of the IECC.

Cost Impact: The code change proposal will not increase or decrease the cost

This section is a problematic and confusing exception that was introduced in the 2024 IECC. Eliminating it does not change the base efficiency requirements of the code, so it will neither increase nor decrease costs for code users.

EC-C402.5.2-24

IECC: C402.5.2

Proponents: DeAnthony Pierce, City of Roanoke, representing Virginia Building & Code Officials Association (deanthony.pierce@roanokeva.gov)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C402.5.2 Minimum skylight fenestration area. Skylights shall be provided in *enclosed spaces* greater than 2,500 square feet (232 m^2) in floor area, directly under a roof with not less than 75 percent of the ceiling area with a ceiling height greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, storage space, gymnasium/exercise center, convention center, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation depot or workshop. The total *toplit daylight zone* shall be not less than half the floor area and shall comply with one of the following:

1. A minimum skylight area to toplit *daylight zone* of not less than 3 percent where all skylights have a VT of not less than 0.40, or VT_{annual} of not less than 0.26, as determined in accordance with Section C303.1.3.
2. A minimum skylight effective aperture, determined in accordance with Equation 4-3, of:

   2.1. Not less than 1 percent using a skylight’s VT rating; or

   2.2. Not less than 0.66 percent using a Tubular Daylight Device’s VT_{annual} rating.

$$\text{Skylight Effective Aperture} = \frac{0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF}}{\text{Toplit Zone}} \quad \textbf{(Equation 4-3)}$$

where:
Skylight area = Total fenestration area of skylights.
Skylight VT = Area-weighted average visible transmittance of skylights.
WF = Area-weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater, or 1.0 for Tubular Daylighting Devices with VT_{annual} ratings.
Light well depth = Measure vertically from the underside of the lowest point of the skylight glazing to the ceiling plane under the skylight.

Exceptions: Skylights above *daylight zones* of *enclosed spaces* are not required in:

1. Buildings in *Climate Zones* 6 through 8.
2. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft^2 (5.4 W/m^2).
3. Areas where it is documented that existing structures or natural objects block direct beam sunlight on not less than half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.
4. Spaces where the *daylight zone* under rooftop monitors is greater than 50 percent of the *enclosed space* floor area.
5. Spaces where the total area minus the area of *sidelit daylight zones* is less than 2,500 square feet (232 m^2), and where the lighting is controlled in accordance with Section C405.2.3.
6. Spaces designed as storm shelters complying with ICC 500.
7. Data centers, or any room or space where the primary function is to house server cabinets.

Reason Statement: This proposal is meant to address the intent of the Energy Conservation Code, by acknowledging the addition of skylights in data halls, as increasing the cooling requirements of those spaces, which are normally designed to stay cool, and typically do not have people within those spaces. This proposal also acknowledges longstanding industry construction of datacenters, and would reduce any confusion regarding skylight requirements.

Cost Impact: The code change proposal will decrease the cost

The code change proposal will decrease the cost of construction and cooling, since it will not require data centers to be re-designed with skylights included.

These building are typically engineered and designed with air-handlers covering the majority of the roof to cool data hall spaces, or rooms that house servers. Skylights will add additional cooling cost to these spaces, as they are primarily designed to remove heat generated by the server and computer equipment, which is counter to Energy Conservation.

RB301.2.1-24

VRC: R301.2.1

Proponents: Chase McArthur, representing Turnkey Porch Enclosures (chase@turnkeyporch.com)

2021 Virginia Residential Code

Revise as follows:

R301.2.1 Wind design criteria. Buildings and portions thereof shall be constructed in accordance with the wind provisions of this code using the ultimate design wind speed in Table R301.2 as determined from Figure R301.2(2). The structural provisions of this code for wind loads are not permitted where wind design is required as specified in Section R301.2.1.1. Where different construction methods and structural materials are used for various portions of a building, the applicable requirements of this section for each portion shall apply. Where not otherwise specified, the wind loads listed in Table R301.2.1(1) adjusted for height and exposure using Table R301.2.1(2) shall be used to determine design load performance requirements for wall coverings, curtain walls, roof coverings, exterior windows, skylights, garage doors and exterior doors. Asphalt shingles shall be designed for wind speeds in accordance with Section R905.2.4. *Metal roof shingles* shall be designed for wind speeds in accordance with Section R905.4.4 . A continuous load path shall be provided to transmit the applicable uplift forces in Section R802.11 from the *roof assembly* to the foundation. Where ultimate design wind speeds in Figure R301.2(2) are less than the lowest wind speed indicated in the prescriptive provisions of this code, the lowest wind speed indicated in the prescriptive provisions of this code shall be used.

Wind speeds for localities in special wind regions, near mountainous terrain, and near gorges shall be based on elevation. Areas at 4,000 feet (1219 m) in elevation or higher shall use the ultimate design wind speed of 140 mph (62.6 m/s) and areas lower than 4,000 feet (1219 m) in elevation shall use the ultimate design wind speed of 110 mph (49.2 m/s). Gorge areas shall be based on the highest recorded speed per locality or in accordance with local jurisdiction requirements determined in accordance with Section 26.5.2 of ASCE 7 .

Exception: Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2.1(1) and the height and exposure factors listed in Table R301.2.1(2). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state “Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s).” Decals shall be placed such that the decal is visible when the panel is installed.

Reason Statement: This amendment proposes an exception under Section R301.2.1 of the 2021 Virginia Residential Code, consistent with existing provisions in North Carolina and Florida. It applies to porches, balconies, and decks with roofs enclosed by removable vinyl or acrylic panels. These enclosures, such as Turnkey’s Oasis 4-Track, are engineered to be flexible and lightweight, offering no structural resistance. Labeled for removal at wind speeds exceeding 75 mph, they revert the porch to open-air status, eliminating additional wind loads on the structure. This clarification fosters consistency across jurisdictions, reduces code ambiguity, and encourages innovation in nonhabitable porch enclosures—ensuring occupant safety without unnecessary structural demand.

Cost Impact: The code change proposal will decrease the cost

The proposal significantly reduces construction costs by preventing misclassification of removable vinyl enclosures as permanent fenestration. This avoids:

- Unnecessary lateral bracing or structural analysis
- Reinforced framing for shear loads
- Use of window-rated glazing systems

The amendment:

- Saves thousands in engineering and material expenses
- Accelerates the permitting and inspection process
- Reduces disputes and promotes code compliance

This exemption preserves the code’s intent—structural safety and clarity—while lowering the burden on outdoor living projects that remain unconditioned and non-habitable.

Attached Files

- **VA Code Ammendment Letter.pdf**
  https://va.cdpaccess.com/proposal/1278/1795/files/download/907/

TURNKEY PORCH ENCLOSURES

Reason Statement, Cost Impact, & Proposed Code Revision

Proposed Amendment to 2021 VRC – R301.2.1 Wind Design Criteria

Reason Statement

This amendment proposes an exception under Section R301.2.1 of the 2021 Virginia Residential Code, consistent with existing provisions in North Carolina and Florida. It applies to porches, balconies, and decks with roofs enclosed by removable vinyl or acrylic panels.

These enclosures, such as Turnkey's **Oasis 4-Track**, are engineered to be flexible and lightweight, offering no structural resistance. Labeled for removal at wind speeds exceeding 75 mph, they revert the porch to open-air status, eliminating additional wind loads on the structure.

This clarification fosters consistency across jurisdictions, reduces code ambiguity, and encourages innovation in non-habitable porch enclosures—ensuring occupant safety without unnecessary structural demand.

Statement on Construction Cost Reduction

The proposal significantly reduces construction costs by preventing misclassification of removable vinyl enclosures as permanent fenestration. This avoids:

- Unnecessary lateral bracing or structural analysis
- Reinforced framing for shear loads
- Use of window-rated glazing systems

The amendment:

- Saves thousands in engineering and material expenses
- Accelerates the permitting and inspection process
- Reduces disputes and promotes code compliance

This exemption preserves the code's intent—structural safety and clarity—while lowering the burden on outdoor living projects that remain unconditioned and non-habitable.

Proposed Code Revision (as submitted to DHCD)

SECTION R301.2.1 – WIND DESIGN CRITERIA

Exception: Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2.1(1) and the height and exposure factors listed in Table R301.2.1(2). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

Submitted by:
Turnkey Porch Enclosures
4109 W Clay Street, Richmond, VA 23230
chase@turnkeyporch.com (804) 567-6543

RB322.3.6-24

VRC: R322.3.6

Proponents: Corian Carney, representing York County (corian.carney@yorkcounty.gov)

2021 Virginia Residential Code

Revise as follows:

R322.3.6 Enclosed areas below required elevation. Enclosed areas below the design flood elevation required in Section R322.3.2 are prohibited in Coastal A Zones and Coastal High Hazard Areas.

Exception: Elevator shaft enclosures designed in accordance with ASCE 24.

Reason Statement: I believe the intent behind this original adoption was to prohibit garages or other storage areas within the Coastal A and Coastal High Hazard areas. I do not believe the intent was to prohibit elevator installations. This may impact elderly or disabled persons who would not otherwise be able to easily access their homes in these areas. See attached interpretation from the State Building Code Technical Review Board.

Cost Impact: The code change proposal will not increase or decrease the cost

as elevators are not required equipment.

Attached Files

- **technical-memos-bulletins-2025-enclosed-area-below-required-elevation-interpretation-1-2025.pdf**
  https://va.cdpaccess.com/proposal/1286/1896/files/download/918/

VIRGINIA STATE BUILDING CODE TECHNICAL REVIEW BOARD

I N T E R P R E T A T I O N

Interpretation Number: 1/2025

Code: USBC, Part I, Virginia Construction Code/2021

Section No: Section R322.3.6

R322.3.6 Enclosed areas below required elevation.

Enclosed areas below the design flood elevation required in Section R322.3.2 are prohibited in Coastal A Zones and Coastal High Hazard Areas.

QUESTION: Would the provision in this section prohibit the installation of elevator shaft enclosures in Coastal A and Coastal High Hazard Areas?

ANSWER: Yes.

QUESTION: If walls are constructed below required flood elevation on three (3) sides of a structure, would that be considered "enclosed" for the purpose of this section?

ANSWER: No.

This Official Interpretation was issued by the State Building Code Technical Review Board at its meeting of April 18, 2024.

____
Chair, State Building Code Technical Review Board

M403.3.1.1-24

IMC®: TABLE 403.3.1.1

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2024 International Mechanical Code

Revise as follows:

TABLE 403.3.1.1 MINIMUM VENTILATION RATES

Portions of table not shown remain unchanged.

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT^2 [a]	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_aCFM/FT^2 [a]	EXHAUST AIRFLOW RATE CFM/FT^2 [a]
Retail stores, sales floors and showroom floors				
~~Dressing rooms~~	—	—	—	~~0.25~~

For SI: 1 cubic foot per minute = 0.0004719 m^3/s, 1 ton = 908 kg, 1 cubic foot per minute per square foot = 0.00508 m^3/(s × m^2), °C = [(°F) – 32]/1.8, 1 square foot = 0.0929 m^2.

a. Based on net occupiable floor area.

b. Mechanical exhaust required and the recirculation of air from such spaces is prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Item 3).

c. Spaces unheated or maintained below 50°F are not covered by these requirements unless the occupancy is continuous.

d. Ventilation systems in enclosed parking garages shall comply with Section 404.

e. Rates are per water closet , urinal or adult changing station. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

f. Rates are per room unless otherwise indicated. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

g. Mechanical exhaust is required and recirculation from such spaces is prohibited. For occupancies other than science laboratories, where there is a wheel-type energy recovery ventilation (ERV) unit in the exhaust system design, the volume of air leaked from the exhaust airstream into the outdoor airstream within the ERV shall be less than 10 percent of the outdoor air volume. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Items 2 and 4).

h. For nail salons, each manicure and pedicure station shall be provided with a source capture system capable of exhausting not less than 50 cfm per station. Exhaust inlets shall be located in accordance with Section 502.20. Where one or more required source capture systems operate continuously during occupancy, the exhaust rate from such systems shall be permitted to be applied to the exhaust flow rate required by Table 403.3.1.1 for the nail salon.

i. Outpatient facilities to which the rates apply are freestanding birth centers, urgent care centers, neighborhood clinics and physicians' offices, Class 1 imaging facilities, outpatient psychiatric facilities, outpatient rehabilitation facilities and outpatient dental facilities.

j. The requirements of this table provide for acceptable IAQ. The requirements of this table do not address the airborne transmission of airborne viruses, bacteria and other infectious contagions.

k. These rates are intended only for outpatient dental clinics where the amount of nitrous oxide is limited. They are not intended for dental operatories in institutional buildings where nitrous oxide is piped.

l. The occupiable floor area in warehouses shall not include the floor area of self-storage units, floor areas under rack storage or designated palletized storage floor areas.

Reason Statement:

This proposal removes the “Dressing Rooms” exhaust requirement listed under retail occupancies in the IMC ventilation table. The current 0.25 cfm/ft² exhaust rate originates from ASHRAE 62.1-2010, Table 6-4, which referenced “Locker/Dressing Rooms” intended for use in facilities like gyms, factories, or similar spaces where personal hygiene and odor control are concerns.
Retail dressing rooms, also called fitting rooms, do not share these characteristics. They are not associated with lockers or showers and pose minimal ventilation concerns. ASHRAE has since clarified through interpretation that the requirement was never intended to apply to retail fitting rooms. This is supported by later versions of ASHRAE 62.1, where “dressing rooms” are no longer listed.
The continued inclusion of dressing rooms under retail in the IMC has led to confusion and over-ventilation. This proposal aligns the code with ASHRAE’s clarified intent and current standards by removing this outdated and misapplied exhaust requirement.

A copy of the interpretation by ASHRAE can be found at the following link - https://www.ashrae.org/File%20Library/Technical%20Resources/Standards%20and%20Guidelines/Standards%20Intepretations/IC_62-1-2010-5.pdf

Cost Impact: The code change proposal will decrease the cost

By not requiring additional exhaust in a typicaly dressing room in a retail setting, the cost for construction will decrease.

M504.4-24

IMC®: 504.4

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2024 International Mechanical Code

Revise as follows:

504.4 Exhaust installation. Dryer exhaust ducts for clothes dryers shall terminate on the outside of the ~~*building*~~ *building.* ~~and shall be equipped with abackdraft damper.~~ Exhaust duct terminations shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct the exhaust flow. Clothes dryer exhaust ducts shall not be connected to a vent connector, vent or *chimney*. Clothes dryer exhaust ducts shall not extend into or through ducts or *plenums*. Clothes dryer exhaust ducts shall be sealed in accordance with Section 603.9.

Reason Statement:

The purpose of a backdraft damper is to minimize air infiltration and prevent rodents and pests from entering the duct system. To effectively serve this purpose, the damper must be located at the duct termination. If it is installed elsewhere along the duct run, air leakage and pest intrusion can still occur between the termination and the damper, defeating its intended function.

In the field, some contractors have attempted to install collapsible inline backdraft dampers within the duct. These installations violate Section 504.4.2 of the International Mechanical Code (IMC), which requires that the exhaust duct remain undiminished in size. Inline dampers reduce the effective diameter of the duct and restrict airflow, resulting in noncompliant and less effective systems.

While the International Residential Code (IRC) clearly states that backdraft dampers are to be installed at the duct termination for dryer exhausts, the IMC lacks similar clarity for general mechanical ventilation systems. This gap in guidance has contributed to inconsistent and often incorrect installations.

This proposal provides necessary clarification by specifying that backdraft dampers must be located at the termination point, ensuring proper function, consistent enforcement, and alignment with best practices found in the IRC.

Cost Impact: The code change proposal will not increase or decrease the cost

This proposal only clarifys the proper location of the backdraft damper. There is no added cost.

M506.3.2.5-24

IMC®: 506.3.2.5, 506.3.2.5.1 Light test., 506.3.2.5.2 Water spray test.

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2024 International Mechanical Code

Revise as follows:

506.3.2.5 Grease Duct Test. ~~A field test shall be performed prior~~ Prior to the use or concealment of any portion of a grease duct ~~system.~~ system, a leakage test shall be performed. Grease ducts shall be considered to be concealed where installed in shafts or covered by coatings or wraps that prevent the grease ducts from being visually inspected on all sides. The permit holder shall be responsible to provide the necessary *equipment* and perform the grease duct leakage test. A light test shall be performed to determine that all welded and brazed joints are liquid tight.

A light test shall be performed by passing a lamp having not less than 1600 lumens through the entire section of ductwork to be tested. The lamp shall be open so as to emit light equally in all directions perpendicular to the duct walls.A light test shall be performed

for the entire grease duct system, including the hood-to-duct connection. The grease duct system shall be permitted to be tested in sections, provided that every joint is tested. For *listed* factory-built grease ducts, this test shall be limited to duct joints assembled in the field and shall exclude factory welds. ~~The test shall be performed in accordance with either Section 506.3.2.5.1 or 506.3.2.5.2.~~

Delete without substitution:

~~**506.3.2.5.1 Light test.**~~ **N/A.** ~~A duct test shall be performed by passing a lamp, having not less than 1600 lumens, through the entire section of ductwork to be tested. The lamp shall be open so as to emit light equally in all directions perpendicular to the duct walls. A successful test shall be where the light from the lamp is not visible at any point on the exterior of the duct.~~

~~**506.3.2.5.2 Water spray test.**~~ **N/A.** ~~A duct test shall be performed by simulating a cleaning operation of the interior of the duct. A water pump capable of a flowing outlet pressure of not less than 1,200 psi (8274 kPa) shall be used, along with any necessary hoses and spray nozzles, to apply high-pressure water to the inside surfaces of the duct. A successful test shall be where there is no evidence of cleaning water at any point on the exterior of the duct.~~

Reason Statement:

This proposal does two things – it changes the lamp requirement of 100 watts to 1600 lumens and it removes the option to perform a water spray test for a grease duct leakage test.

Since the phase-out of incandescent lamps and the widespread adoption of LED technology, the lighting industry has shifted from measuring brightness in watts to using lumens as the standard metric. Watts indicate energy consumption, not light output, and are no longer a reliable way to gauge brightness with modern lighting. Lumens measure the actual amount of visible light produced by a lamp. For reference, a 100-watt incandescent bulb typically produces around 1600 lumens, which is now the benchmark used to compare LED lamp brightness.

The 2024 IMC introduces an option to conduct grease duct leakage testing using a water spray method. While this may offer an alternative to traditional testing, it presents several practical and safety concerns when used in both new or existing spaces. If leaks are present, water may escape the ductwork, creating hazards such as contact with temporary electrical wiring, slip risks on floors, and potential damage to finished or in-progress construction. Additionally, introducing water into the duct system can promote corrosion, especially if not properly dried or maintained afterward.

From an inspection standpoint, verifying the effectiveness of a water spray test is highly challenging. It is unclear how an inspector can ensure that the spray adequately contacts all welds or penetrates micro-leaks, particularly given water's surface tension properties. This calls into question the reliability and practicality of the method for field verification.

Cost Impact: The code change proposal will decrease the cost

The cost of an LED lamp is less than the cost of a rig to water spray test the duct.

M508.2-24

IMC®: 508.2

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2024 International Mechanical Code

Revise as follows:

508.2 Compensating hoods. Manufacturers of compensating hoods shall provide a label indicating the minimum exhaust flow, the maximum makeup airflow or both that provides capture and containment of the exhaust ~~effluent.~~effluent. Makeup air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate.

Exception: Compensating hoods with *makeup air* supplied only from the front face discharge and side face discharge openings shall not be required to be *labeled* with the maximum makeup airflow.

Reason Statement:

Virginia removed the kitchen hood section of VECC C403.7.5 in its entirety from the 2018 VECC due to a conflict between the maximum exhaust flow rate defined by the energy code being less than the minimum flow rate required for grease and smoke removal for unlisted hoods in the mechanical code. Although pertaining only to compensating hoods, the sentence “Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate” was also deleted as part of that amendment.

The sentence “Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate” was originally added to the 2015 IECC as a result of improved kitchen hood testing standards that indicated thermal plume spillover outside the hood for supplies internal hood supply air rates of greater than 10 percent that would not be detected by the standard UL710 testing.

Since this sentence is intended to increase smoke and grease capture of commercial hoods, it should be added back in to either the VECC or the VMC.

Cost Impact: The code change proposal will not increase or decrease the cost

There is no additional cost because it was never intended to allow greater than 10 percent makeup air to be directly introduced into the hood cavity.

M607.6.2.2-24

VMC: 607.6.2.2; VCC: 717.6.2.2

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2021 Virginia Mechanical Code

Delete without substitution:

~~**607.6.2.2** **Equipment shutdown.** Where ceiling radiation dampers are listed as static dampers, the HVAC *equipment* shall be effectively shut down to stop the airflow prior to the damper closing using one of the following methods:~~

1. ~~A duct detector installed in the return duct.~~
2. ~~An area smoke detector interlocked with the HVAC *equipment*.~~
3. ~~A listed heat sensor installed in the return duct.~~

2021 Virginia Construction Code

Delete without substitution:

~~**717.6.2.2** **Equipment shutdown.** Where ceiling radiation dampers are listed as static dampers, the HVAC *equipment* shall be effectively shut down to stop the airflow prior to the damper closing using one of the following methods:~~

1. ~~A duct detector installed in the return duct.~~
2. ~~An area smoke detector interlocked with the HVAC *equipment*.~~
3. ~~A listed heat sensor installed in the return duct.~~

Reason Statement: This code section was a previous Virginia amendment to the International Mechanical Code. Previously, radiation dampers listed as static dampers were not addressed in the code. During the 2021 code update cycle, the IMC addressed this topic in sections 607.6.2.1, 607.6.2.1.1 and 607.6.2.1.2. When Virginia adopted the 2021 IMC with amendments, the Virginia code section and the sections in the IMC were never correlated and both code sections remained. This proposal deletes the Virginia amendment.

Cost Impact: The code change proposal will not increase or decrease the cost

This proposal will not increase of decrease the cost of construction.

M1109.2.5-24

IMC®: 1109.2.5 Refrigerant pipe shafts., 1109.3.2 Shaft ventilation.

Proponents: Greg Johnson, Johnson & Associates Consulting Services, representing self (gjohnsonconsulting@gmail.com)

2024 International Mechanical Code

Revise as follows:

1109.2.5 Refrigerant pipe shafts. N/A. Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure. The fire-resistance-rated shaft enclosure shall comply with Section 713 of the *International Building Code*.

Exceptions:

1. *Refrigeration* systems using R-718 refrigerant (water).
2. Piping in a direct refrigeration system ~~using Group A1 refrigerant~~ where the refrigerant quantity does not exceed the limits of Table 1103.1 for the smallest occupied space through which the piping passes.
3. Piping located on the exterior of the *building* where vented to the outdoors.

1109.3.2 Shaft ventilation. N/A. ~~Refrigerant~~ <u>Required refrigerant</u> pipe shafts with systems using Group A2L or B2L refrigerant shall be naturally or mechanically ventilated. Refrigerant pipe shafts with one or more systems using any Group A2, A3, B2 or B3 refrigerant shall be continuously mechanically ventilated and shall include a refrigerant detector. The shaft ventilation exhaust outlet shall comply with Section 501.3.1. Naturally ventilated shafts shall have a pipe, duct or conduit not less than 4 inches (102 mm) in diameter that connects to the lowest point of the shaft and extends to the outdoors. The pipe, duct or conduit shall be level or pitched downward to the outdoors. Mechanically ventilated shafts shall have a minimum airflow velocity in accordance with Table 1109.3.2. The mechanical ventilation shall be continuously operated or activated by a refrigerant detector. Systems utilizing a refrigerant detector shall activate the mechanical ventilation at a maximum refrigerant concentration of 25 percent of the lower flammable limit of the refrigerant. The detector, or a sampling tube that draws air to the detector, shall be located in an area where refrigerant from a leak will concentrate. The shaft shall not be required to be ventilated for double-wall refrigerant pipe where the interstitial space of the double-wall pipe is vented to the outdoors.

Reason Statement:

The proposed change to Sec 1109.2.5 is identical to IMC code change M75-24 which is on the consent agenda for the 2027 IMC. The limitation of Exc. 2 of IMC Sec. 1109.2.5 to Group A1 refrigerants was - as documented by the original proponent, Julius Ballanco - a mistake that happened when a draft document from an ASHRAE 15 work group was submitted as part of a very large code change (M99-18) in the 2018 IMC development year.

ASHRAE 15 has never limited the exception (Sec. 9.12.1.5.1, shaft alternative in ASHRAE terminology) to only Group 1 refrigerants; doing so would compromise the purpose of ASHRAE Standard 34, Table 4-1I (IMC Table 1103.1, Refrigerant Classification, Amount and OEL), which provides safe release limits for all refrigerants. The proposed change to IMC Sec. 1109.3.2 clarifies that only where a shaft is required (because safe release limits could be exceeded) should ventilation and drainage be required. This would permit A2L refrigerant piping below safe release limits to be run in a shaft for convenience without ventilation and drainage, just as if it were run through some other building cavity.

Cost Impact: The code change proposal will decrease the cost

Designer clients have told me that the cost of ventilated and drained shafts for A2L piping in a 300 unit apartment building is around $300K.

M-FG407.2-24

IFGC: 407.2

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2024 International Fuel Gas Code

Revise as follows:

407.2 Design and installation. *Piping* shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers or building structural components, suitable for the size of *piping*, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. *Piping* shall be anchored to prevent undue strains on connected *appliances* and shall not be supported by other *piping*. Pipe hangers and supports shall conform to the requirements of MSS SP-58 and shall be spaced in accordance with Section 415. Supports, hangers and anchors shall be installed so as not to interfere with the free expansion and contraction of the *piping* between anchors. The components of the supporting *equipment* shall be designed and installed so that they will not be disengaged by movement of the supported *piping*.

Reason Statement: Gas piping should never be supported with plastic hangers or support. In a fire situation, these supports can melt causing gas pipe to break which can cause a catastrophic incident.

Cost Impact: The code change proposal will not increase or decrease the cost

There is no additional cost because the 2021 VUSBC already requires metal supports.

RM-FG2415.7-24

IRC: G2415.7 (404.7); IFGC: 404.7

Proponents: Dennis Hart, Fairfax County, representing VPMIA/VBCOA (dennis.hart@fairfaxcounty.gov)

2024 International Residential Code

Revise as follows:

G2415.7 (404.7) Protection against physical damage. Where *piping* will be concealed within *light-frame construction* assemblies, the *piping* shall be protected against penetration by fasteners in accordance with Sections G2415.7.1 through G2415.7.3.

Exception: Black steel *piping* with a wall thickness Schedule 40 or greater and galvanized steel *piping* shall not be required to be protected.

2024 International Fuel Gas Code

Revise as follows:

404.7 Protection against physical damage. Where *piping* will be concealed within light-frame construction assemblies, the *piping* shall be protected against penetration by fasteners in accordance with Sections 404.7.1 through 404.7.3.

Exception: Black steel *piping* ~~and~~ with a wall thickness Schedule 40 or greater and galvanized steel *piping* shall not be required to be protected.

Reason Statement: With the code now permitting the use of Schedule 10 black steel pipe, it is essential to require protection against screw and nail penetrations for black steel piping that is not Schedule 40. Schedule 10 piping has a thinner wall thickness than Schedule 40. Additionally, Type L and K copper, which have a greater wall thickness than Schedule 10 black steel, are already required to be protected. Therefore, it is only logical that Schedule 10 black steel piping should also be protected.

Cost Impact: The code change proposal will not increase or decrease the cost

Protection is still required for piping.

RE3601.8-24

IRC: E3601.8, E3601.6.2

Proponents: Corian Carney, York County, representing Virginia Chapter IAEI, Eastern Virginia Division IAEI (corian.carney@yorkcounty.gov); Charles Stiles, Spotsylvania County, representing VA Chapter IAEI (cstiles@spotsylvania.va.us); Joseph Willis, Prince William County, representing Virginia Chapter IAEI (jwillis@pwcgov.org)

2024 International Residential Code

Delete without substitution:

~~**E3601.8 Emergency disconnects.** For one- and two-family *dwelling units*, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:~~

1. ~~Service disconnects marked as follows: EMERGENCY DISCONNECT, SERVICE DISCONNECT.~~
2. ~~Meter disconnect switches that have a short-circuit current rating equal to or greater than the available fault current and all metal housings and service enclosures are grounded in accordance with Section E3908.7 and bonded in accordance with Section E3609. A meter disconnect switch shall be capable of interrupting the load served and shall be marked as follows: EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT.~~
3. ~~Other *listed* disconnect switches or circuit breakers that are marked suitable for use as service equipment, but not marked as suitable only for use as service equipment and marked as follows: EMERGENCY DISCONNECT, NOT SERVICE EQUIPMENT.~~

~~Markings shall comply with Section E3404.12 and both of the following:~~

1. ~~The marking or labels shall be located on the outside front of the disconnect enclosure with red background and white text.~~
2. ~~The letters shall be at least $\frac{1}{2}$ inch (13mm) high. [230.82 (3), 230.85]~~

Revise as follows:

E3601.6.2 Service disconnect location. The service disconnecting means shall be installed ~~at~~ in a readily accessible ~~location either outside of a *building* or inside nearest the point of entrance of the service conductors.~~ outdoor location in accordance with one the following:

1. On the dwelling unit.
2. Within sight of the dwelling unit in accordance with E3405.8

Service disconnecting means shall not be installed in bathrooms. Each occupant shall have *access to* the disconnect serving the *dwelling unit* in which they reside. [230.70(A)(1)(2), 230.72(C)]

Reason Statement: The proposed regulations for the 2026 National Electrical Code remove the options for Emergency Disconnects from Article 230 (Services), and relocate them to Article 225 (Feeders). The language in the 2020 and 2023 National Electrical Code unintentionally contradicts intent in other code sections related to service conductors and grounding electrode system connection. Removal of this language from the 2024 Virginia Residential Code will allow Virginia to keep up with more current safety standards provided by the National Electrical Code, and eliminate confusion between contractors and building department staff.

Cost Impact: The code change proposal will decrease the cost
by eliminating potential for multiple disconnecting means being installed or from reworking of installations due to confusion or misinterpretation of the code language.

Attached Files

- **70_A2025_NEC_P10_FD_BallotFinal.pdf**
  https://va.cdpaccess.com/proposal/1259/1893/files/download/925/

First Revision No. 9155-NFPA 70-2024 [Section No. 230.70]

230.70 General.

Means shall be provided to disconnect all ungrounded conductors in a building or ~~other~~ structure from the service conductors.

(A) Service Disconnect Location.

~~The service disconnecting means~~ Service disconnects shall be installed in accordance with 230.70(A)(1), 230.70(A)(2), 230.70(A)(3), and 230.70(A)(4).

(1) Readily Accessible Location.

~~The service disconnecting means~~ Service disconnects shall be installed at a readily accessible location either outside of a building or structure or inside nearest the point of entrance of the service conductors.

(2) One- and Two-Family Dwellings.

Service disconnects shall be installed in a readily accessible outdoor location on or within sight of the one- or two-family dwelling unit.

(3) Bathrooms.

Service disconnecting means shall not be installed in bathrooms.

(4) Remote Control.

~~Where a~~ If a remote- control device(s) is used to actuate the service ~~disconnecting means~~ disconnect, the service ~~disconnecting means~~ disconnect shall be located in accordance with 230.70(A)(1). Remote-control devices shall not be used as a service disconnect for one- and two-family dwellings.

(B) Service Disconnect Marking.

~~Each service disconnect shall be permanently marked to identify it as a service disconnect~~ Service disconnects shall be marked in accordance with 230.70(B)(1) and 230.70(B)(2).

(1) Marking.

Service disconnects shall be marked as “SERVICE DISCONNECT” and the marking shall comply with 110.21(B).

(2) One- and Two-Family Dwellings.

Service disconnects for one- and two-family dwellings shall be marked as follows:

EMERGENCY DISCONNECT, SERVICE DISCONNECT

Markings shall comply with 110.21(B) and both of the following:

(1) The markings shall be located on the outside front of the disconnect enclosure with a red background and white text.

(2) The letters shall be at least 13mm (1/2 in.) high.

(C) Suitable for Use.

~~Each service disconnecting means shall be suitable for the prevailing conditions.~~ Service equipment installed in hazardous (classified) locations shall comply with the hazardous location requirements.

(D) Identification of Other Source Disconnects.

Where equipment for disconnection of other energy source systems is not located adjacent to the service disconnect required by this section, a plaque or directory identifying the location of all equipment for disconnection of other energy sources shall be located adjacent to the service disconnect.

Informational Note: See 445.18 , 480.7 , 705.20 , and 706.15 for examples of other energy source system disconnection means.

(E) Replacement.

Replacement of service equipment for one- and two- family dwellings shall comply with 230.70(A) , 230.70(B) , and 230.70(C) .

Exception: If only meter sockets, service entrance conductors, or related raceways and fittings are replaced, the requirements of 230.70(A)(2) and 230.70(B)(2) shall not apply.

Supplemental Information

File Name	Description	Approved
70_NEC_CMP10_A2025NEC_230.70_FR9155.docx	For staff use only	
70_NEC_CMP10_A2025NEC_230.70_FR9155.docx	For prod use	

Submitter Information Verification

Committee: NEC-P10

Submittal Date: Thu Jan 25 15:02:03 EST 2024

Correlating Committee Actions

The correlating committee may override this FR with a First Correlating Revision or with a Committee Note

Create FCR or CN

Committee Statement

Committee Statement: Requirements related to emergency disconnects found in Section 230.85 of the NEC have caused confusion for the electrical industry since it was not clear what specific types of disconnects were allowed to meet the requirements. It was also unclear how to ensure the emergency disconnect equipment is protected from available fault current. In addition, there has been confusion when applying the requirements for grounding and bonding of Article 250 when an emergency disconnect is installed on the supply-side of a service disconnecting means. This First Revision in conjunction with other First Revisions to 230.82 and 230.85, do not delete requirements for emergency disconnects for one-and two family dwellings, rather the requirements are greatly simplified by requiring the service disconnecting means for the dwelling to be located at a readily accessible location on the outside of the dwelling. Such service disconnecting means will also serve as the emergency disconnect for one- and- two family dwellings. This change will resolve issues related to what type of equipment can be installed for the emergency disconnect, how grounding and bonding is required to be installed, and the issues related to available fault current are addressed by the fact that service equipment is required to have appropriate overcurrent protection.

The concerns of the submitter for Public Input 2191 have been addressed with the First Revision of 230.70. The specific marking is added to better align with the requirement in 230.70(B)(2).

Concerning Public Input 2512, removing the existing requirement does not change the requirements already specified in the NEC. Such existing text is unnecessary. The second sentence is retained as it’s considered to provide clarity.

Response Message: FR-9155-NFPA 70-2024

Public Input No. 2191-NFPA 70-2023 [Section No. 230.70(B)]

Public Input No. 2023-NFPA 70-2023 [Section No. 230.70(C)]

Public Input No. 2512-NFPA 70-2023 [Section No. 230.70(C)]

Public Input No. 2022-NFPA 70-2023 [Section No. 230.70(B)]

Public Input No. 2021-NFPA 70-2023 [Section No. 230.70(A)]

Public Input No. 2582-NFPA 70-2023 [Section No. 230.70(A)(1)]

Ballot Results

✔ **This item has passed ballot**

18 Eligible Voters
0 Not Returned
15 Affirmative All
3 Affirmative with Comments
0 Negative with Comments
0 Abstention

Affirmative All

Anderson, Jr., Richard P.

Arnold, Kevin S.

Blizard, Scott A.

Dawes, Anthony John

Dollar, Randy

Gomez, Adam Wesley Thomas

Hansen, Clint Lee

Lofton, II, Richard E.

Philips, Nathan

Pisani, Mark K.

Robey, Derrick

Schmidt, Alan

Sparks, III, Roy K.

Wingate, Mark W.

Zia, Danish

Affirmative with Comment

Ayer, Lawrence S.

List item (4) as presently written doesn't work. Just because a remote control device is used doesn't mean the disconnect should not be readily accessible. All service disconnects are readily accessible.

Koepke, Ed

No comment

Williams, David A.

The new requirements of 230.70(A)(2) uses the phrase "within sight". However, if the definition of “within sight” is deleted (since such definition includes requirements, which is a violation of the Style Manual) then a direct reference to 110.29 will be required for determining the maximum distance of 50 feet to still be considered within sight. For example, in 225.31(B) we added: “within sight of the building in accordance with 110.29.” This section also needs the reference to 110.29.

First Revision No. 9179-NFPA 70-2024 [Section No. 230.85]

~~**230.85** Emergency Disconnects.~~

~~For one- and two-family dwelling units, an emergency disconnecting means shall be installed.~~

~~**(A)** General.~~

~~**(1)** Location.~~

~~The disconnecting means shall be installed in a readily accessible outdoor location on or within sight of the dwelling unit.~~

~~*Exception: Where the requirements of 225.41 are met, this section shall not apply.*~~

~~**(2)** Rating.~~

~~The disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.~~

~~**(3)** Grouping.~~

~~If more than one disconnecting means is provided, they shall be grouped.~~

~~**(B)** Disconnects.~~

~~Each disconnect shall be one of the following:~~

(0) ~~Service disconnect~~

(0) ~~A meter disconnect integral to the meter mounting equipment not marked as suitable only for use as service equipment installed in accordance with 230.82~~

(0) ~~Other listed disconnect switch or circuit breaker that is marked suitable for use as service equipment, but not marked as suitable only for use as service equipment, installed on the supply side of each service disconnect~~

> ~~Informational Note 1: Conductors between the emergency disconnect and the service disconnect in 230.85(2) and 230.85(3) are service conductors.~~

> ~~Informational Note 2: Equipment marked "Suitable only for use as service equipment" includes the factory marking "Service Disconnect".~~

~~**(C)** Replacement.~~

~~Where service equipment is replaced, all of the requirements of this section shall apply.~~

~~*Exception: Where only meter sockets, service entrance conductors, or related raceways and fittings are replaced, the requirements of this section shall not apply.*~~

~~**(D)** Identification of Other Isolation Disconnects.~~

~~Where equipment for isolation of other energy source systems is not located adjacent to the emergency disconnect required by this section, a plaque or directory identifying the location of all equipment for isolation of other energy sources shall be located adjacent to the disconnecting means required by this section.~~

> ~~Informational Note: See 445.18 , 480.7 , 705.20 , and 706.15 for examples of other energy source system isolation means.~~

~~**(E)** Marking.~~

~~(1) Marking Text.~~

~~The disconnecting means shall marked as follows:~~

(0) ~~Service disconnect~~

~~EMERGENCY DISCONNECT, SERVICE DISCONNECT~~

(0) ~~Meter disconnects installed in accordance with 230.82 (3) and marked as follows:~~

~~EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT~~

(0) ~~Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are marked suitable for use as service equipment and marked as follows:~~

~~EMERGENCY DISCONNECT, NOT SERVICE EQUIPMENT~~

~~(2) Marking Location and Size.~~

~~Markings shall comply with 110.21(B) and both of the following:~~

(0) ~~The marking or labels shall be located on the outside front of the disconnect enclosure with red background and white text.~~

(0) ~~The letters shall be at least 13 mm (½ in.) high.~~

Submitter Information Verification

Committee: NEC-P10

Submittal Date: Thu Jan 25 16:00:42 EST 2024

Correlating Committee Actions

The correlating committee may override this FR with a First Correlating Revision or with a Committee Note

Create FCR or CN

Committee Statement

Committee Statement: In conjunction with the proposed First Revision to section 230.70, section 230.85 has been proposed to be deleted as emergency disconnects are now service disconnects.

Response Message: FR-9179-NFPA 70-2024

Public Input No. 2578-NFPA 70-2023 [Section No. 230.85]

Public Input No. 2583-NFPA 70-2023 [Section No. 230.85]

Public Input No. 3801-NFPA 70-2023 [Section No. 230.85]

Public Input No. 1925-NFPA 70-2023 [Sections 230.85, 230.85]

Public Input No. 4427-NFPA 70-2023 [Section No. 230.85(B)]

Ballot Results

✔ **This item has passed ballot**

18 Eligible Voters

0 Not Returned

17 Affirmative All

1 Affirmative with Comments
0 Negative with Comments
0 Abstention

Affirmative All

Anderson, Jr., Richard P.

Arnold, Kevin S.

Ayer, Lawrence S.

Blizard, Scott A.

Dawes, Anthony John

Dollar, Randy

Gomez, Adam Wesley Thomas

Hansen, Clint Lee

Lofton, II, Richard E.

Philips, Nathan

Pisani, Mark K.

Robey, Derrick

Schmidt, Alan

Sparks, III, Roy K.

Williams, David A.

Wingate, Mark W.

Zia, Danish

Affirmative with Comment

Koepke, Ed

No comment

RE3901.4.2-24

IRC: E3901.4.2

Proponents: Joseph Willis, representing Prince William County (jwillis@pwcgov.org)

2024 International Residential Code

Revise as follows:

E3901.4.2 Island and peninsular countertops and work surfaces. Receptacle outlets, if installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with Section E3901.4.3. ~~If a receptacle outlet is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface.~~

Reason Statement:

The language in the 2024 International Residential Code provides the installer the option to either install a receptacle outlet or provide future provisions for a receptacle outlet at peninsular and island work surfaces. By eliminating the language to allow for future provisions, the temptation to perform unpermitted and potentially non-compliant work will be drastically decreased as the convenience of having future provisions will no longer be available. In addition, the temptation to utilize extension cords from a nearby receptacle to place a small appliance on these work surfaces is also eliminated. This particular code section is the only code section in the electrical provisions of the 2024 IRC that allows the installation of wiring for future use and one of only six times that "future" is used as it pertains to installations for use at an undetermined time. The other instances apply to plumbing as it relates to drainage and venting and mechanical and gas sections pertaining to dryer exhaust duct. The specific requirements to have receptacle outlet serve island and peninsular countertop work surfaces has been a requirement since the 1990 edition of NFPA 70, The National Electrical Code. This code change proposal to the 2024 Virginia Residential Code fully addresses the safety deficiencies identified by the NFPA in the commentary for the 2023 Edition of the National Electrical Code.

Cost Impact: The code change proposal will not increase or decrease the cost

This code change proposal will have no cost impact to the owner/designer/contractor chooses to install receptacles on the island and/or peninsular countertop work surfaces. In addition to the zero-cost impact, the removal of the future provisions will save money in the long run as the cost of material and labor continue to increase.

RE3902.20-24

VRC: E3902.20

Proponents: Corian Carney, York County, representing Virginia Chapter IAEI, Eastern Virginia Division IAEI (corian.carney@yorkcounty.gov); Joseph Willis, Prince William County, representing Virginia Chapter IAEI (jwillis@pwcgov.org)

2021 Virginia Residential Code

Revise as follows:

E3902.20 Arc-fault circuit interrupter protection. Branch circuits that supply 120-volt, single-phase, 15- and 20- ampere outlets installed in kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, *sunrooms*, recreations rooms, closets, hallways, laundry areas and similar rooms or areas shall be protected by any of the following: [210.12(A)]

1. A *listed* combination-type arc-fault circuit interrupter, installed to provide protection of the entire branch circuit. [210.12(A)(1)]
2. A *listed* branch/feeder-type AFCI installed at the origin of the branch-circuit in combination with a *listed* outlet branch-circuit-type arc-fault circuit interrupter installed at the first outlet box on the branch circuit. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit. [210.12(A)(2)]
3. A *listed* supplemental arc-protection circuit breaker installed at the origin of the branch circuit in combination with a *listed* outlet branch-circuit-type arcfault circuit-interrupter installed at the first outlet box on the branch circuit where all of the following conditions are met:
   - 3.1. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.
   - 3.2. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 50 feet (15.2 m) for 14 AWG conductors and 70 feet (21.3 m) for 12 AWG conductors.
   - 3.3. The first outlet box on the branch circuit shall be marked to indicate that it is the first outlet on the circuit.[210.12(A)(3)]
4. A *listed* outlet branch-circuit-type arc-fault circuit interrupter installed at the first outlet on the branch circuit in combination with a *listed* branch-circuit overcurrent protective device where all of the following conditions are met:
   - 4.1. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.
   - 4.2. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 50 feet (15.2 m) for 14 AWG conductors and 70 feet (21.3 m) for 12 AWG conductors.
   - 4.3. The first outlet box on the branch circuit shall be marked to indicate that it is the first outlet on the circuit.
   - 4.4. The combination of the branch-circuit overcurrent device and outlet branch-circuit AFCI shall be identified as meeting the requirements for a system combination-type AFCI and shall be *listed* as such. [210.12(A)(4)]
5. Where metal raceways, metal wireways, metal auxiliary gutters or Type MC or Type AC cable meeting the applicable requirements of Section E3908.9 with metal boxes, metal conduit bodies and metal enclosures are installed for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, a *listed* outlet branch-circuit type AFCI installed at the first outlet shall be considered as providing protection for the remaining portion of the branch circuit. [210.12(A)(5)]
6. Where a *listed* metal or nonmetallic conduit or tubing or Type MC cable is encased in not less than 2 inches (50.8 mm) of concrete for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, a *listed* outlet branch-circuit-type AFCI installed at the first outlet shall be considered as providing protection for the remaining portion of the branch circuit. [210.12(A)(6)]

Exceptions:

1. AFCI protection shall not be required for an individual branch circuit supplying a fire alarm system where the branch circuit is installed in a metal raceway, metal auxiliary gutter, steelarmored cable, Type MC or Type AC, meeting the requirements of Section E3908.9 , with metal boxes, conduit bodies and enclosures.
2. ~~AFCI protection is not required where GFCI protection is required in accordance with Section E3902 and NEC 210.8(A).~~

Reason Statement: The previous exemption for arc-fault requirements where ground-fault protection is required allowed for a grace period to adjust to the full requirements. Prior to that exemption, AFCI protection was only required in bedrooms. This proposal will bring Virginia back in line with the national safety standard provided in NFPA 70 (NEC).

Cost Impact: The code change proposal will increase the cost

Cost will increase by approximately $60-$120 per new construction home to account for 1-2 additional AFCI devices.